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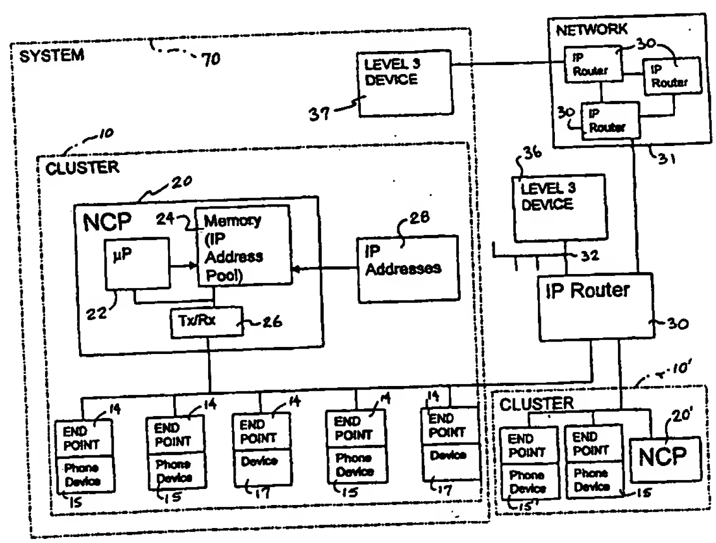

(57) Abstract

In a data network system (31, 70, 36, 30, 10') and/or process for communications between endstations (15', 17) which are routed through an IP network (30, 31) precious and distinctive addresses, typically IP addresses are not permanently associated with each endstation, but rather are only transiently related to some relatively versatile endstations (15, 17). Precious IP addresses are collected, dispensed and assigned to versatile endstations from a subnetwork-based pool of IP addresses (24, 28) according to network call like cycle events. At the start and then at the end of any call between a versatile end station and any other end station, a network controller (20) will perform assignment/dispensation from, and then return to, a pool of unique IP addresses such that even a versatile endstation has a unique IP address for the duration of the call.

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DYNAMIC IP ADDRESS ASSIGNMENT

CROSS REFERENCE TO RELATED APPLICATION

This is a non provisional application claiming the benefit of provisional application 60/104,653 filed October 16, 1998.

FIELD OF THE INVENTION

The invention relates in general to IP address assignment as well as a telephone system which is operated using a data network, such as a local area network and more particularly to the use of such a system in both level 2 and level 3 network environments.

BACKGROUND OF THE INVENTION

Computer networks or data networks connect a plurality of devices to each other using a network architecture. Most network architectures provide several different layers. Each layer is responsible for providing some service to the layer above and does this by using the services of the layer below. The open systems interconnection (OSI) reference model defines seven layers for computer networks. There is no special importance as to the number seven. However the reference model provides some guidance for designers. Protocols that are used for the various levels have evolved over time and some of the various layers have been subdivided into further layers.

Generally the first or lowermost level is referred to as the physical layer. This layer has responsibility to transmit unstructured bits of information across a link of the network. The physical layer deals with such problems as size and shape of connectors, assignment of functions to pins, conversion of bits to electrical signals, and bit-level synchronization. It is usual for several different types of physical layers to exist within a network and even for multiple different types of physical layers to exist within a node (also referred to herein as an end station or end point device), as each technology requires its own physical layer. For example, a node with an Ethernet attachment and an attachment to a 56Kb synchronous line will have implemented two different physical layers.

Layer two is generally considered the data link layer which has the responsibility to transmit chunks of information across a link. Level two deals with such problems as check summing to correct data corruption; orderly coordination of the use of shared media, as in a

LAN (Local Area Network); and addressing when multiple systems are reachable, as in a LAN. The addressing is accomplished with so-called MAC (Media Access Controller) addresses. Specifically, each networkable device has assigned to it a unique MAC address for use at the so-called layer two. Devices can communicate with each other based on the MAC addresses. Data packets may be switched based on MAC addresses. It is common for layer two links to implement different data link layers and for a node (or end point) to implement several data link layer protocols, one to support each of the different types of links to which the node is attached (as discussed above with regard to layer one).

Layer three is normally referred to as the network layer. Layer three has the responsibility to enable any pair of systems in the network to communicate with each other. A fully connected network is one in which every pair of nodes has a direct link between them. However, this type of topology is not used as it does not scale beyond a few nodes. Accordingly, in a more typical case, the network layer must find a path through a series of connected nodes, the nodes along the path must forward packets in the appropriate direction. The network layer deals with such problems as route calculation, packet fragmentation and reassembly (different links in the network have different maximum packet sizes), and congestion control.

With the more frequent use of the Internet, Internet protocol (IP) addressing has been more extensively used at layer three. Routers and other layer three devices typically have address lookup tables wherein a packet which has an IP encapsulation (namely an IP address added to the packet) can be directed or routed by a router (or a network of routers) based on

the use of a lookup table of route entries which represent individual IP addresses and groups of IP addresses -often bit contiguous (there is a commonality between leading bits of addresses).

Computer and telephone networks have historically been provided based on separate physical infrastructures and are normally separately managed. Computers which are connected to the global Internet require IP addresses in order to communicate with other computers around the world. For this reason, layer three devices often use layer three IP addressing. These same computers can communicate on local networks without the need for IP addresses by using layer two switching using MAC addresses. However, typically, IP addresses are used and layer three routing and interconnection is provided.

Telephone systems have typically been provided as PBX systems or similar systems with line cards or other connections to the public phone system and with various telephones connected back to a central exchange device. The PBX systems include digital systems wherein a proprietary protocol or other some phone-based protocol is used. With such systems, most telephones do not have an IP address. Trying to converge the infrastructure such that the telephone system operates over a computer network poses some challenges, particularly with regard to addressing. If a company were to replace its telephone system with a new IP-based phone system, they would need to double (or more) the number of IP addresses they use. Thus, efficient management of the limited IP version 4 address space is an important consideration for such a converged infrastructure.

An IP address allocation scheme referred to as DHCP (Dynamic Host Configuration

Protocol) is known. This protocol functions for environments which are primarily at level three. With DHCP the devices lease an IP address for their primary method of communication. While such DHCP leases can be short term in nature, the lessee usually cannot do anything meaningful without the IP address. This presents the problem of not being able to have communication within the subnet based on MAC addresses or the like.

Typically level three packets are encapsulated in IP (Internet Protocol) and may be routed by routers based on IP addresses. MAC addresses, which are globally unique, may be used for switching at level two, namely switching based on MAC addresses. Typically with IP encapsulation, the destination and source IP addresses are provided.

By utilizing level two functions, a system may be provided which is able to communicate without an IP address and hence does not require an IP address for normal usage. However as the traffic is directed to outside of the local net, it is necessary to use the router MAC address and then use IP encapsulation including both the IP destination address and IP source address. The DHCP system is not optimized for systems relying primarily on level two addressing and a system which primarily uses level two addressing presents the problem as to functioning in a routed level three environment.

SUMMARY AND OBJECTS OF THE INVENTION

It is an object of the invention to provide a system which operates using a computer network infrastructure wherein a plurality of devices at network endpoints are connected via the network (a subnet) and at least some of the devices do not have Internet protocol (IP)

addresses. For traffic beyond the subnet, or other traffic that requires an IP address, a network control processor (NCP) is provided which allocates IP addresses to the device on an as-needed basis.

The devices connected via the network (a subnet) wherein at least some of the devices do not have Internet protocol (IP) addresses are preferably telephone devices. The telephone devices may be e.g. phones, TLIMs (Telephone Line Interface Modules), PSTN (Public Switch Telephone Network) gateways, T1 gateways, H323 gateways, etc., computers etc. In this text, the term telephone device is intended to include a telephone unit that has a handset and has a transmitter and receiver function for placing audio level two (2) packets (e.g., packets with MAC addresses) on a network and for receiving such data packets. The telephone device may also be a computer that has a sound card for audio input and output and a connection to the network (e.g., via a network interface card which includes the transmitter and receiver function for placing level two packets on the network and for receiving such data packets). The telephone device may also be a TLIM or other device for converting one format of telephone signaling to another form of telephone signaling (e.g., proprietary) and may also be for audio format conversion (one packet format to another) and for converting an audio format to another -e.g., analog acoustic to a digital packet).

The system of the invention eliminates the need for a large number of IP addresses to be allocated, namely an IP address allocated to each end point, such as each telephone device attached to a network. Instead, a pool of IP addresses is maintained wherein the total number of IP addresses in the pool is preferably less than the total number of phone devices connected

to the subnet. The allocation on an as-needed basis reduces the complexity and overhead of managing the IP address space.

According to the invention a system is provided, which has features for the management of IP addresses. The system has a number of devices located on the same level two network (a subnetwork or cluster of devices which can communicate with level two addresses). At least some of the devices have no IP address. Occasionally, one or more of these devices needs to communicate with a device located on a different subnet (an IP subnetwork) or a device with an IP address on the subnet. Communication between two of the devices using IP addressing may also be provided.

One device of the subnetwork or "cluster" can be a controller for the subnet. The controller may also be connected to the network. The device controller is either active in handing out IP addresses or only responds to IP address requests. The device controller may or may not be the same device which controls other features and functions of the overall system (the system may include for example the cluster itself as well as other devices not located on the same level two network).

According to a preferred embodiment of the invention, the device controller or network control processor (NCP) knows the status of all the devices in the system. Specifically, the devices are connected to allow communication between devices. The NCP can note the desire of any particular device to communicate with other devices in the system but which are not in the cluster, or in a wholly separate system (which may or may not be on the same level two network but are connected to the cluster). The system preferably provides that the devices

direct requests to the NCP. Upon the receipt of such a request, the device controller allocates to the device an IP address from a pool of IP addresses designated for the cluster. Such a pool of IP addresses may be maintained in a memory associated with the device controller. Upon notification that the device no longer needs to communicate outside the cluster, the device controller reclaims the IP address and returns the address to its pool for allocation to another requesting device. The device controller may use another protocol (DHCP) from another controller or DHCP server to allocate this pool of IP addresses. The provision of the IP address can be automatic or manual DHCP can be used by the NCP to obtain multiple IP addresses wherein the lease for such addresses can be renewed as needed.

The preferred embodiment of the invention is thus able to allow communication without an IP address, within the cluster and hence does not require an IP address for normal usage. In this normal function, the system communicates exclusively via level two protocols when possible, and only uses level three protocols when necessary. If a level two device (with no IP address and only a level two address) needs to communicate with a level three device, the level two device is assigned an IP address for the duration of the call. The IP address is revoked at call termination or at some point after the call terminates. Accordingly, the pool of IP addresses may be maintained small and the number of IP address space resources required for the overall system is a function of the maximum number of expected calls between routed networks (e.g., the number or requests for communication between a device on the subnet with no IP address and a device with an IP address and connected to the subnet), and is not a unitary function of the number of devices in the system. As a single device controller or network control processor

can be designed to be switched at level two, then IP addresses are needed only when devices are making inter-domain calls (calls to be routed using a level three router to a different domain).

According to another embodiment of the invention, the device itself (e.g., phone or phone system in a computer) recognizes that it needs to communicate outside of the cluster, and makes a request to the device controller for an IP address. The device uses the IP address received for the duration of the communication, and releases the IP address back to the device controller at the end of the call. The device may or may not use an existing protocol such as DCHP to grab an IP address. Protocols such as DHCP can be used and allow the device controller (DHCP server) to be located on a different subnet than the entire cluster itself. In that case (no DCHP server on the same subnet) software known as BOOTP relay agent can be installed or activated on a router to relay the level 2 DHCP request or level 2 request to the appropriate DCHP server or domain controller.

According to another aspect of the invention, a process for allocating IP addresses is employed with a system with devices which normally communicate at level two and require an IP address for communication via an IP router to another cluster or subnetwork. The system utilizes a plurality of phone devices without IP addresses and a Network Control Processor (NCP) which controls level two communication between the devices. The process includes detecting when a phone (A), without an IP address, goes off hook. A level two packet is sent to the NCP, informing the NCP of the off hook state of the phone (A). A number for another phone (C) is dialed at the phone (A). The digits dialed are sent as a level two packet to the

NCP. When the NCP detects that the phone (A) without the IP address and the phone (C) corresponding to the number dialed are not on the same level two network (and the phone dialed has an IP address but the phone that dialed does not have an IP address) the NCP accesses an IP address from an IP address pool maintained by the NCP. The pool is for use with devices on the same level two network as the NCP. The NCP then sends a level two packet to the phone (A) with one of the IP addresses from the pool and instructs the phone (A) to use the IP address for the duration of the call (e.g. A.A.A.A). The NCP also instructs the phone (A) to talk to the other phone (C) based on the known IP address (e.g., C.C.C.C). The phone (A) then grabs the IP address (e.g., A.A.A.A) and broadcasts an ARP (Address Resolution Protocol) message to the Local Area Network so as to advise the other devices on the local subnet. The phone (A) then begins to send audio packets, encapsulated as IP packets, to the other phone. The source IP address of the IP packets is e.g., A.A.A.A and the destination IP address of the IP packets is e.g., C.C.C.C. Upon completion of the call, either phone (A) or the other phone (C) hangs up. The phone (A) sends its information to the NCP via a level two packet if it is phone (A) or via a level three IP packet or level two packet if it is the other phone (C). The NCP upon receiving the packet indicating the termination of the call instructs the phone (A) to terminate the call and stop sending IP audio packets to the other phone. The NCP also instructs the phone (A) that it no longer has the IP address which has been allocated.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and specific objects attained by its uses,

reference is made to the accompanying drawings and descriptive matter in which preferred embodiments of the invention are illustrated.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

Figure 1 is a diagram showing system components according to the invention;

Figure 2 is a diagram showing the system according to the invention with a level 2 packet exchange between devices in a subnet or cluster;

Figure 3 is a diagram showing aspects of a call setup for an exchange of packets between telephones using level 2 addressing and level 2 protocols;

Figure 4 is a diagram showing a call setup using dynamic Internet protocol address assignment according to the invention;

Figure 5 is a diagram showing a call setup with a temporarily assigned IP address;

Figure 6A is a flow diagram for illustrating steps involving the assignment of an IP address; and

Figure 6B is another flow diagram illustrating steps involving the assignment of an IP address.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings in particular, the invention comprises a network system and process involving a plurality of interconnected devices defining a data network. The network

is referred to as a subnetwork or cluster 10 and includes a physical connection 12 (such a connection may also be based on wireless interconnection schemes such as radio frequency RF connections and infrared (IR) connections) between end points 14. The end points include devices, which may be for example telephone units, computers, TLIMs or other telephone devices 15. The end points also may have other devices 17 besides telephone devices. The devices may include a network interface with a transmitter and receiver. The phone devices 15 also include a processor and also generate audio data packets. At least some of the devices 15 and 17 have no IP address. Preferably all of the devices have a MAC address for communication over the network 12 with level two packets (e.g., destination and source address). The end points 14 may have devices for interconnection to other subnetworks or networks such as routers 30, bridges or switches. The cluster 10 according to a preferred embodiment of the invention also includes a network control processor (NCP) 20. The Network Control Processor 20 monitors traffic over the network 12 and/or receives packets from other devices. The network 12 can implement any one of numerous protocols such as ETHERNET (IEEE802.3 using for example 10 base T or other physical media schemes). Although the preferred embodiment of the invention is based on an ETHERNET type network, the invention can be practiced using various physical layers and various layer 2 protocols. The preferred embodiment relates generally to a Local Area Network as the cluster 10 however other networks including Wide Area Networks, networks established based on the public phone system and/or the Internet they also employ the system. However, the invention primarily provides the cluster 10 wherein most communication between the end points 14 may take place

using level 2 addressing (e.g. the MAC addresses) associated with each device or end station at each end point 14. Further, the invention is not limited to a phone system using the subnet. The invention also applies to other devices with a MAC address and with no IP address, which can send and receive level two packets (e.g., packets using MAC addressing).

The NCP 20 monitors traffic over the network and controls communication between end points 14 which involves audio communication, namely telephone communication with data packets. Besides the telephone communication using level 2 packets, exchanged between end points 14, the network interconnection 12 may be used for data exchange between computers, using the ETHERNET protocol as mentioned above.

The NCP 20 includes a processor or an intelligent device 22 as well as a transmitter and receiver 26 and a memory 24. The memory 24 establishes an IP (Internet Protocol) address pool wherein a plurality of IP addresses are maintained or accessed. The IP addresses are first obtained in a known manner and input into the memory as shown at 28. The number of IP addresses which are provided in the memory IP address pool 24 depends upon the anticipated or expected calls between an end point 14 and an end point or device which is not on the local subnet or cluster 10.

The devices at end points 14 include telephone units which have no IP address. These telephone units do have a MAC address which facilitates layer 2 communication between any of the various phones at end points 14 and the NCP 20. As shown in Figure 2 a telephone device A with no IP address can initiate a telephone call to device B which also has no IP address wherein these devices are connected over the network connection 12 of the local subnet

or cluster 10. To set up the call the NCP 20 sends a packet on the network connection 12 which includes the device A MAC address and signals device A to talk directly to device B using device B's level 2 address. Similarly, the NCP 20 signals device B to talk directly to device A using device A's level 2 address. The packet exchange between device A and device B occurs at level 2 wherein the packets include the MAC addresses, namely the destination and source MAC address.

As shown in Figure 4, the system of the invention also allows communication between a phone 15 or device 17 at an end point 14 and a phone or device 36 connected to another network, subnet or the like wherein the subnet or cluster 10 is connected to the other network or subnet via a level 3 router (IP router) 30 or routers 30 or a network of routers 31. Specifically, the IP router 30 as shown in Figure 1 is a level 3 device which for example may maintain a lookup table of IP addresses or groups of IP addresses for determining where a packet is to be forwarded to. Normally, the term router refers to a device which can handle level 3 addresses. Most typically, the level 3 addresses use the so-called IP (Internet Protocol) addressing. Switches also provide a similar function and level 2 switches are known which provide switching using level 2 addressing. Traffic to an entity outside a devices subnet 10 is provided with the MAC address to the router 30 with an IP address inside the packet. The router then can encapsulate the packet with the destination IP address and source IP address. The IP router may also be considered a level 2/level 3 interface. Devices know whether the destination of a packet is on the same subnet or different subnet based on a subnet mask which can be maintained by the intelligent devices. A function of a source device IP address, a source

devices subnet mask, a destination devices IP address is to indicate whether or not a destination is on the same subnet, level two network or logical level 2 subnet as the source. When a device communicates to another device on a same subnet using IP an ARP request is generated. The source device responds with its own hardware address (MAC) and the two devices can communicate at level 2 or level 3 as both source and destination have MAC and IP address. The IP router has knowledge that some end-point or device on the subnet has an IP address corresponding to the received ARP broadcast. The router or destination device fills in its own hardware address and responds to the requesting device. It may also put the hardware address in its own ARP table. The ARP request involves a response of devices on the same net. Also, intermediate devices may make proxy responses for devices not on the net. Virtual LAN concepts can be used with the system of the invention.

As shown in Figure 4, where a device with no IP address such as device A at end point 14 wishes to set up a call with a device on a different subnet or connected via the level 3 interface (the IP router 30) the NCP 20 must first assign it one of the IP addresses from the IP address pool 24. The call setup is shown in the diagram of Figure 5. The NCP 20 assigns device A with a level 3 address by sending a level 2 packet to device A. NCP 20 then signals device A to talk to device C using device C's level 3 address. Similarly, the control unit signals to device C to talk directly to device A using device A's temporary level 3 address. The packet exchange between devices A and C occurs at level 3 via the router 30 (or network 32 with a network of routers, subnets etc.). When the call is done, the NCP tells device A and C to terminate the call. Then, the NCP 20 revokes device A's level 3 address.

As to the router 30, the router may assign the temporary IP address to a particular devices MAC address in its ARP lookup table, but this may be changed during subsequent calls.

Figure 6A shows a flow diagram of process steps involved in a call which requires the assignment of an IP address as discussed above.

The process of the invention is initiated at 60 as the phone A, namely a device 15 in the subnet or cluster 10 which has no IP address, has its status changed to off-hook. This may be for example by lifting a handset or otherwise actuating the phone A. Phone A is at an end point 14 connected via network connection 12 and provided in a subnet or cluster 10. The change of status to off-hook results in level 2 packets being sent to the NCP 20 informing the NCP 20 that phone A is off-hook. This is shown in the flow diagram at number 62. Number 64 shows the subsequent state wherein phone C (for example with number 234) is dialed on phone A. This results in the digits being sent in level 2 packets to the NCP 20. The subsequent step 66 is shown wherein the NCP 20 knows that phone A (at number 123) and phone C (at number 234) are not on the same level 2 network. The NCP 20 knows that phone C (at number 234) already has an IP address but that phone A (at number 123) does not have an IP address. The subsequent step at 68 involves the NCP accessing an IP address from the address pool 24. The processor 22 can use any one of a number of algorithms for accessing the IP address including accessing the next available IP address. Another algorithm can be implemented if there are no IP addresses available. However, typically a number of IP addresses are available and the NCP signals to the IP address pool 24 to read out an IP address from memory which is to be assigned to one of the devices on the same level two network as the NCP 20. At the

subsequent step 70 the NCP 20 sends a level two packet to phone A with an IP address read out from the IP address pool (e.g. A.A.A.A) and instructs phone A to use this IP address for the duration of the call. At the subsequent 72 step the NCP 20 instructs phone A to talk to phone C (number 234) which is at IP address C.C.C.C. (see also Figures 4 and 5). At the subsequent step 74 phone A (number 123) grabs the IP address A.A.A.A and advises the local subnet (cluster 10) by broadcasting an ARP message to the local network. That is, a level 2 packet is sent addressed to each end point 14 of the subnet 10 using the address resolution protocol (ARP). At the subsequent step 76 the phone A sends audio packets encapsulated as internet protocol packets to phone C (at number 234). The source IP address of the IP packets is A.A.A.A and the destination IP address of the IP packets is C.C.C.C. This is received at the interface or IP router 30 which forwards the packets to the subnet 50 based on the destination IP address. In the opposite direction the phone C sends audio packets encapsulated as IP packets to the phone A (at number 123). The source IP address of the packets is C.C.C.C and the destination IP address of the IP packets is A.A.A.A. Based on the address resolution protocol broadcast the router 30 knows that an entity on the subnet or cluster 10 has the IP address of the earlier ARP broadcast. Packets are exchanged during the phone conversation as shown for example in Figure 5. Subsequently the process continues to step 78 wherein either phone A or phone C hangs up. The phone that hangs up sends this info to the NCP 20 via a level 2 packet or via a level 3 IP packet (in the case of phone A) or a level 3 IP packet (in the case of phone C). The NCP 20 then instructs phone A to terminate the call, to stop sending IP audio packets to phone C and it indicates that it no longer has the IP address A.A.A.A. This

last step is shown at 80 in Figure 6.

The system of the invention also allows a phone device with an IP address to call a phone device or other device (15,17 etc.) which has no IP address. The process is similar to the process described with reference to Figure 6A. As shown in Figure 6B a phone C (x234) with an IP address goes off hook at shown at 82. As indicated at 84, phone C (x234) sends level three packet to NCP 20 informing the NCP that phone C is off hook. Phone A is dialed at 86. The digits are sent in level three packets to be NCP 20. The NCP 20 knows that phone C has an IP address and knows that phone A (x123) has no IP address as indicated at step 88. Next, the NCP 20 grabs an IP address from the address pool 24 as indicated at 90. As shown at 92 the NCP 20 sends a level two packet to phone A with the IP address (e.g. A.A.A.A) and instructs phone A to use this IP address for the duration of the call. At 94 the NCP sends a level 2 packet to phone A instructing phone A to talk to phone C which is at a particular IP address (e.g., C.C.C.C). Phone A grabs the IP address and advises the local subnet by broadcasting ARP messages to the local network as indicated at 96. Phone A and phone C exchanged audio packets encapsulated as IP packets as indicated at 98. Either phone A or phone C terminates the call as indicated at 100. The NCP 20 instructs phone A to terminate the call, to stop sending IP audio packets to phone C and that it no longer has the address that was assigned (e.g. A.A.A.A) as indicated at 102.

The process of the invention for using the system of the invention can also provide phone devices on the same subnet with IP addresses for communication using level 3 packets. The invention is not limited in any way to the phones or other devices being on different

subnets. Either or neither of the phone devices or other devices may have no IP address. The NCP may assign in IP address to either phone device or other device. Even though it is advantageous to provide communication with level two packets, communication on the same subnet may be provided with level three packets.

According to another embodiment of the invention the system includes devices which can be in a single cluster 10 or can be distributed (in multiple clusters or individual devices or a combination thereof), all logically associated with the same NCP 20 (see Figure 1). For example, the level 3 device 37 in Figure 1 can be logically part of a system 70 controlled by NCP 20.

According to yet another embodiment of the invention, the system of the invention can be used in two wholly separate systems controlled by two separate NCPs 20, 20', respectively, wherein a phone device 15 in one system which does not have an IP address may wish to contact a phone device 15' in a different system or subnet 10' which also does not have an IP address. The NCP 20 follows a procedure in which:

1) The calling phone device 15 is activated and dials a number which indicates the destination phone device 15' directly (unified/universal dial plan), or which maps to a specific system (system code) and then to the phone device 15' on that system (system-specific extension).

2) The NCP 20 recognizes that the number dialed is not a phone device within its system, and determines the system which controls the destination phone device 15' (either by looking up the system code in a local database or by contacting some external device which can

perform the mapping).

3) In an exchange of signaling messages, the NCP 20 for the system for the calling phone device contacts the NCP 20' for the system of the destination phone device and indicates to the other NCP 20' that the source device 15 is trying to reach the destination phone device 15'.

4) Prior to or during this exchange of signaling messages, the NCP for the system of the source (calling) phone 15 assigns an IP address to the source phone 15, and passes this information to the NCP 20' for the system of the destination (called) phone device 15'.

5) During the exchange of the signaling messages, if the destination phone device is activated, the NCP for the system of the destination device assigns the destination phone device an IP address and passes this information back to the NCP for the system of the calling device.

6) If the destination phone device 15' does not answer and the source phone device 15 also hangs up prematurely, an IP address may or may not be assigned to the source phone device 15. The preferred method is that the IP address assignment happens when the call is connected to the destination phone device 15' or audio recording device (i.e., voicemail on the destination system).

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles.

WHAT IS CLAIMED IS:

1. A system for data networks, the system comprising:

a network interconnecting a plurality of end station devices, each end station device having a level 2 address and some or all of said end station devices having no assigned Internet protocol address;

a network controller connected to said network interconnection, said network controller, said network interconnection and said end station devices cooperating to define a subnetwork with devices communicating in the subnetwork using level 2 packets;

an IP address pool associated with said network controller, said IP address pool corresponding to a plurality of IP addresses, said network controller assigning one of said IP addresses to one of said phones upon a communication being initiated which requires or involves level 3 addressing.

2. The device according to claim 1, wherein said all of said end station devices having no assigned Internet protocol address are telephone devices.

3. The device according to claim 1, wherein the number of IP addresses provided by said IP address pool is less than a number of said some or all of said end station devices having no assigned Internet protocol address.

4. The device according to claim 1, wherein said network is a subnetwork and wherein said assigning of an IP address by said controller occurs upon a communication being initiated which involves a device on said subnetwork and a connection by an interface to a device not on said subnetwork.

5. The device according to claim 4, further comprising a level 3 interface connected to said subnetwork for providing level 3 connections between said subnetwork and a network or network devices connected to said interface.

6. The device according to claim 1, wherein the network controller establishes telephone calls between phones as end station devices based on packets exchanged between end station devices with level 2 MAC addresses only.

7. The system according to claim 1, wherein the network interconnection provides an ETHERNET type network connection.

8. A system according to claim 1, wherein at the termination or subsequent to the termination of the call the device which had been assigned the IP address from the IP address pool no longer has the IP address.

9. A process for operating a telephone system using a data network with a network

connection between end points with phone devices connected at respective end points and a network controller connected to the network, the phone devices and network controller each having a unique MAC address, the process comprising:

providing telephone communication between phone devices using the controller to initiate the sending of packets between devices which are to communicate, using MAC addresses only;

providing an IP address pool which can be addressed by said network controller, said IP address pool having a number of IP addresses which is less than a number of phone devices connected to the network; and

upon a phone device connected to the network initiating a phone call to a device not connected to the network, assigning one of said plurality of IP addresses to the phone device.

10. The process according to claim 9, wherein said step of initiating a phone call to a device not on the network include sending a packet with a MAC address only from a phone device which goes off hook, informing the network controller of the off hook status;

dialing at the network phone device a number which corresponds to a device which is not on the subnetwork resulting in sending a level 2 packet to the network controller indicating the number of a device not on the subnetwork;

and at the network controller determining that the phone device which has dialed and the phone device dialed are not on the same level 2 network and determining that the phone device dialed has an IP address and the phone device which has dialed does not have an IP

address.

11. The process according to claim 9, wherein a phone device with an IP address calls a phone device without an IP address and the process includes generating a broadcast ARP (Address Resolution Protocol) message.

12. The process according to claim 9, wherein said step of accessing the IP address pool includes obtaining an IP address from the address pool and sending a packet with a MAC address only from the network controller to the phone device, which packet includes the IP address for instructing the phone device to use the IP address for the duration of the call and instructing the phone device to communicate with the other phone device which has a particular IP address.

13. The process according to claim 9, wherein a phone device with an IP address calls a phone device without an IP address and the process includes generating a broadcast ARP (Address Resolution Protocol) message.

14. The process according to claim 9, further comprising upon receiving an IP address packet from the network controller, the phone device broadcasts an ARP message to the local subnetwork indicating that the phone device has the IP address which the network controller has assigned to it; and subsequently sending audio packets, encapsulated as IP packets to the

other phone device wherein the IP source address is the address assigned to the phone device and the destination IP address is the IP address of the other phone device.

15. The process according to claim 9, wherein each phone device has no IP address such that two IP addresses are assigned by the NCP for a call and the process includes generating a broadcast ARP (Address Resolution Protocol) messages for each phone device.

16. The process according to claim 9, wherein upon one of the phone device and the other phone device hanging up, the phone device which hangs up sends a packet to the network controller wherein the packet is a level 2 packet of sent by the phone device and the packet is a level 3 packet if sent by the other phone device.

17. The process according to claim 9, wherein upon termination of a call, the phone device stops sending IP audio packets to the other phone device and the phone device no longer has the IP address assigned to it by the network controller.

18. A process for operating a system using a data network with a network connection between end points with devices connected at respective end points and a network controller connected to the network, the devices and network controller each having a unique MAC address and at least some of the devices not having a permanently assigned IP address, the process comprising:

providing communication between devices using the controller to initiate the sending of packets between devices which are to communicate, using MAC addresses only;

providing an IP address pool which can be addressed by said network controller, said IP address pool having a number of IP addresses; and

upon a device connected to the network initiating a communication to a device wherein one or both devices have or require an IP address for communication or if communication is desired using IP addressing, assigning an IP addresses from said pool to one or both of said devices.

19. The process according to claim 18, wherein said step of initiating a communication to a device includes:

sending a packet with a MAC address only, from a device for informing the network controller of the desire to initiate communication with another device; and

at the network controller determining that one or both of the devices to be involved in the communication has or requires an IP address or that the device dialed has an IP address.

AMENDED CLAIMS

[received by the International Bureau on 18 February 2000 (18.02.00); original claim 16 amended; remaining claims unchanged (1 page)]

generating a broadcast ARP (Address Resolution Protocol) messages for each phone device.

16. The process according to claim 9, wherein upon one of the phone device and the other phone device hanging up, the phone device which hangs up sends a packet to the network controller wherein the packet is a level 2 packet if sent by the phone device and the packet is a level 3 packet if sent by the other phone device.

17. The process according to claim 9, wherein upon termination of a call, the phone device stops sending IP audio packets to the other phone device and the phone device no longer has the IP address assigned to it by the network controller.

18. A process for operating a system using a data network with a network connection between end points with devices connected at respective end points and a network controller connected to the network, the devices and network controller each having a unique MAC address and at least some of the devices not having a permanently assigned IP address, the process comprising:

providing communication between devices using the controller to initiate the sending of packets between devices which are to communicate, using MAC addresses only;

providing an IP address pool which can be addressed by said network controller, said IP address pool having a number of IP addresses; and

upon a device connected to the network initiating a communication to a device

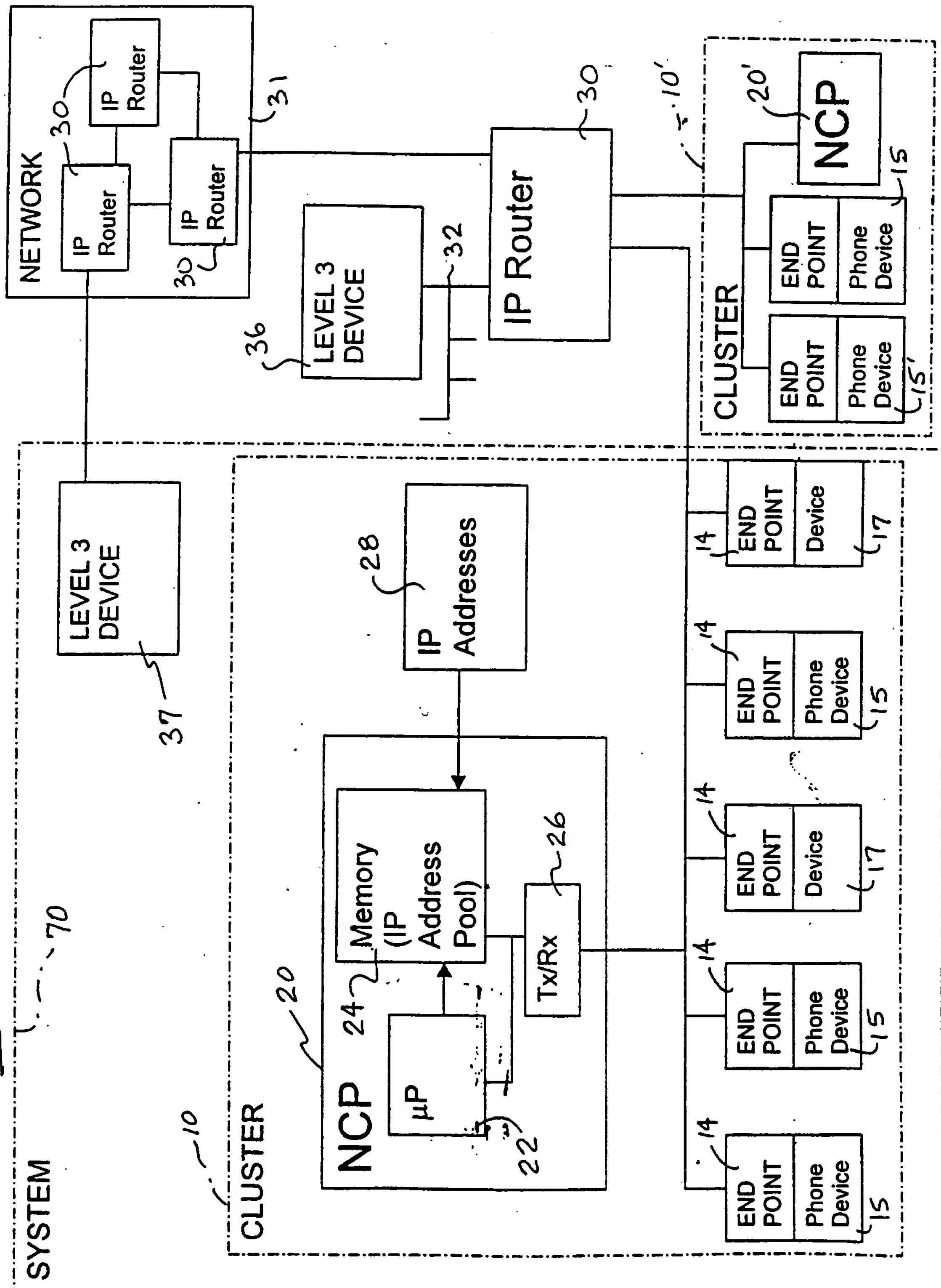
NETWORK
IP Router
IP Router
IP Router
30
30
30
31
IP Router
30
10'
NCP
20'
CLUSTER
END POINT
Phone Device
15
END POINT
Phone Device
15'
LEVEL 3 DEVICE
36
32
SYSTEM
70
LEVEL 3 DEVICE
37
CLUSTER
10
NCP
20
μP
22
24
Memory (IP Address Pool)
IP Addresses
28
Tx/Rx
26
END POINT
Device
14
17
END POINT
Phone Device
14
15

Fig. 1

1.1 Diagram of Normal Call Setup

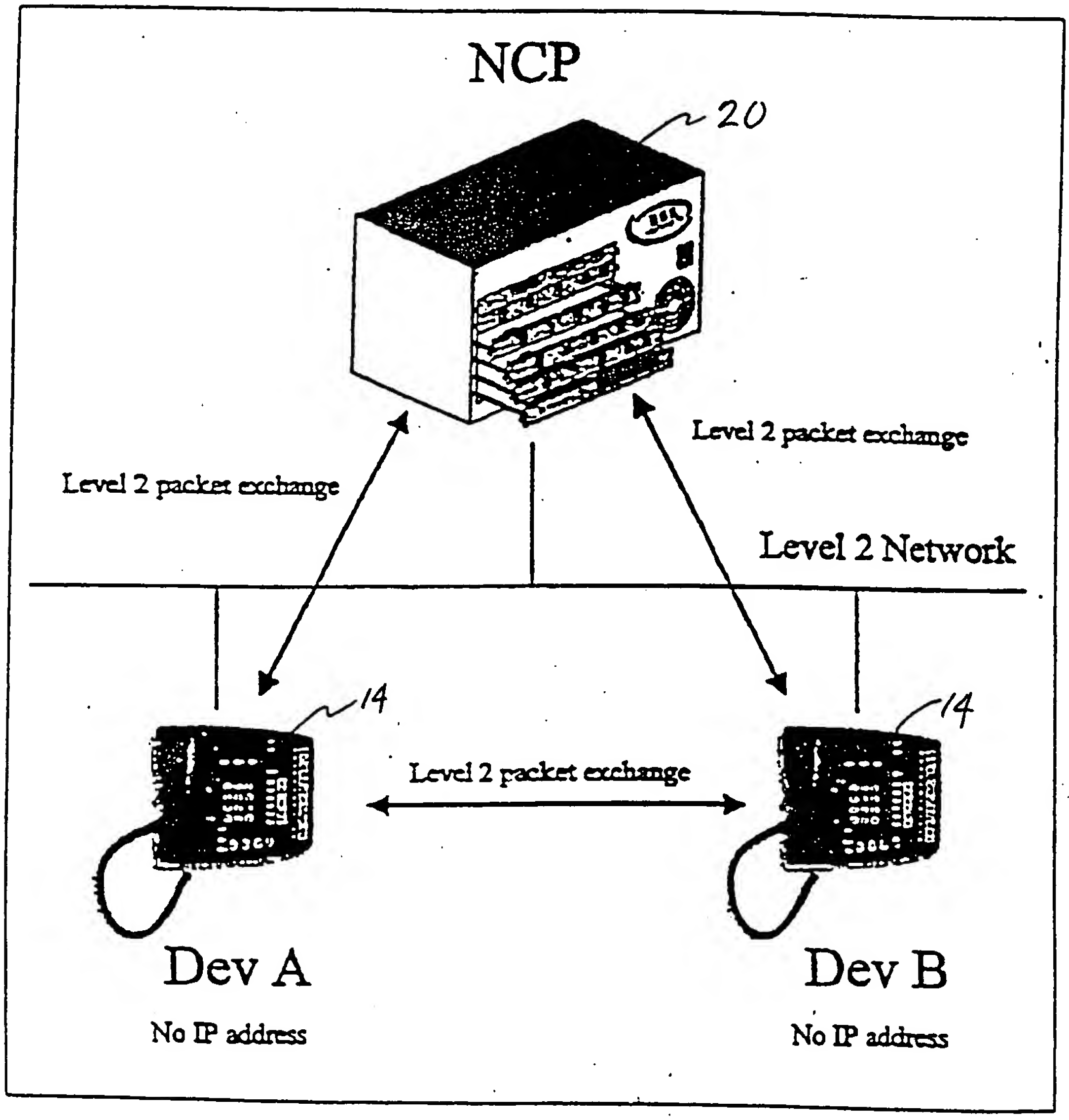

Fig. 2

In this call setup, the control unit signals (via Level 2) to device A to talk directly to device B using device B's level 2 address. Similarly, the control unit signals to device B to talk directly to device A using device A's level 2 address. The packet exchange between devices A and B occurs at Level 2.

1.2

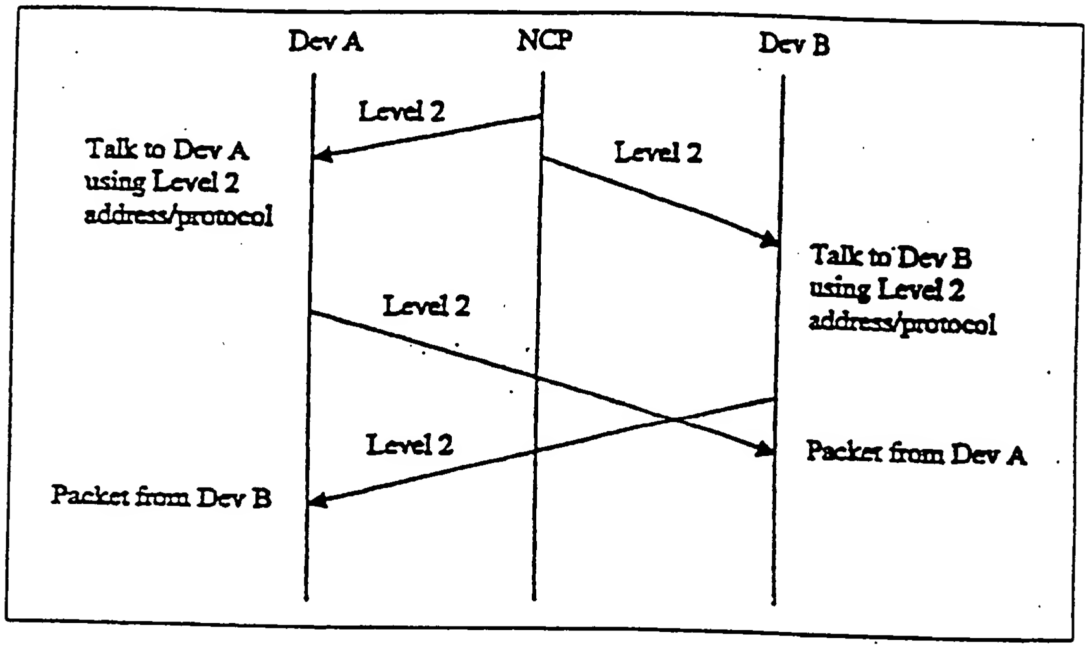

Fig. 3

Diagram of a Call Setup Using Dynamic IP Address Assignment

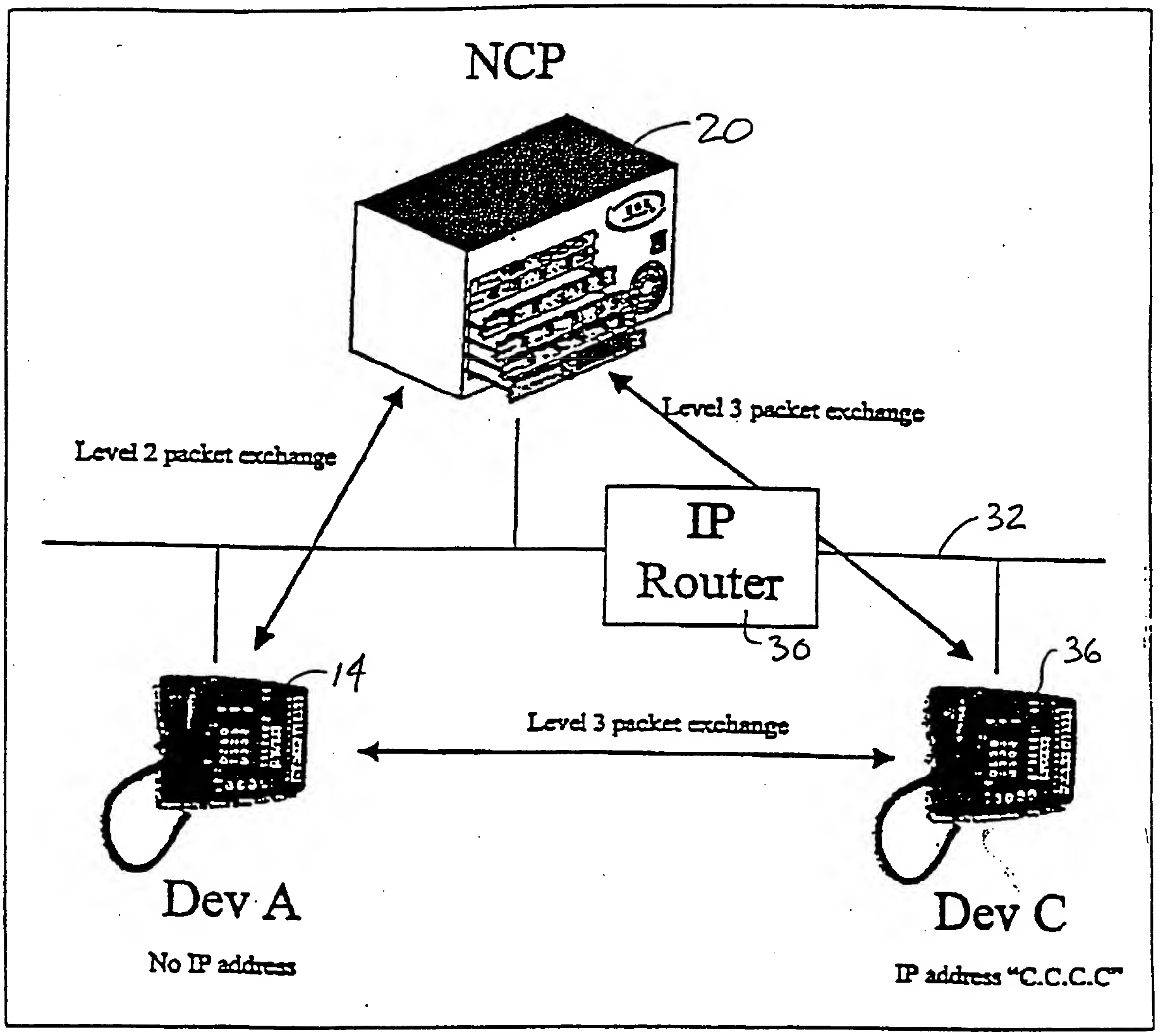

Fig. 4

In this call setup, the control unit assigns (via Level 2 communications) device A a Level 3 address. The NCP then signals device A to talk to device C using device C's level 3 address. Similarly, the control unit signals to device C to talk directly to device A using device A's temporary level 3 address. The packet exchange between devices A and C occurs at Level 3. When the call is done, the NCP tells device A and C to terminate the call. Then, the NCP revokes device A's Level 3 address.

29

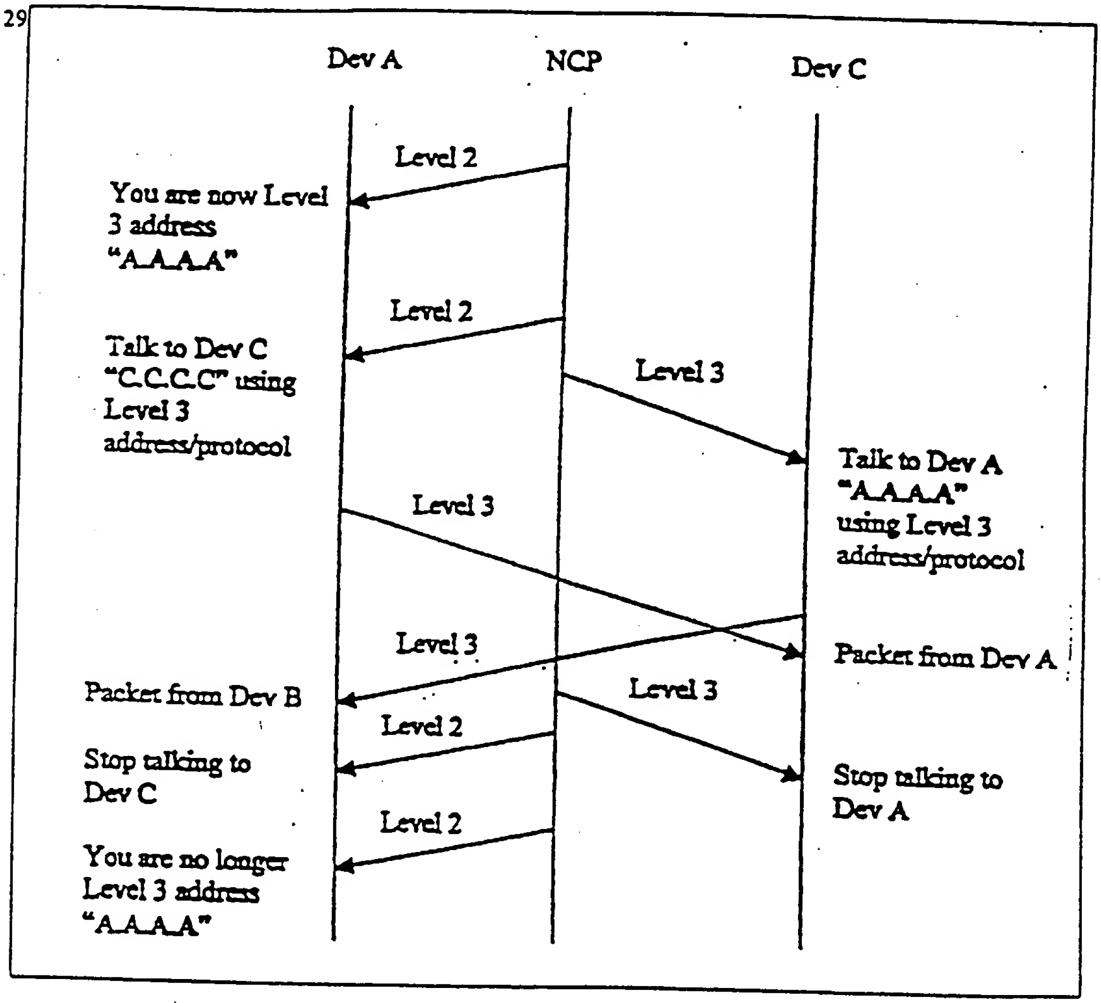

Fig. 5

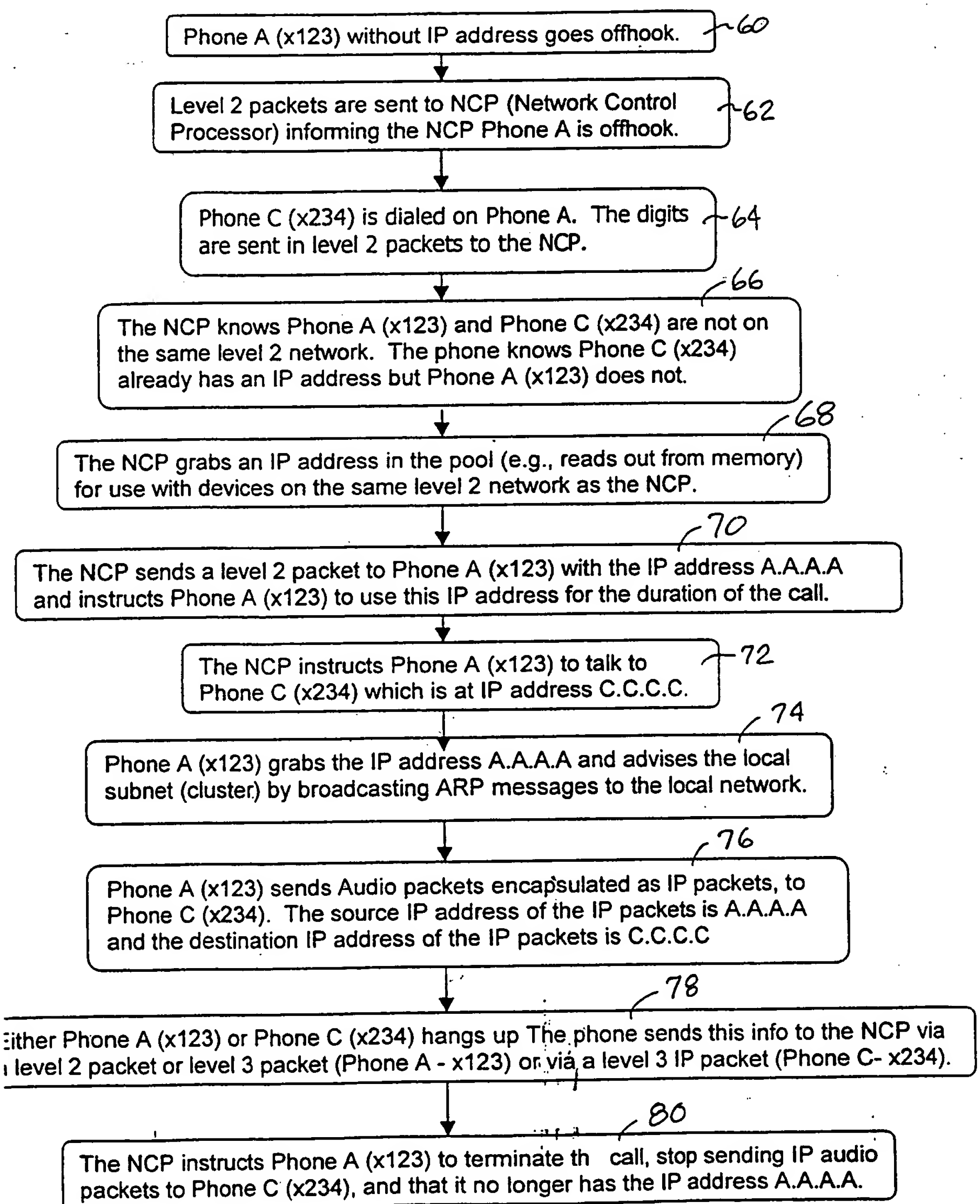
Phone A (x123) without IP address goes offhook.
60
Level 2 packets are sent to NCP (Network Control Processor) informing the NCP Phone A is offhook.
62
Phone C (x234) is dialed on Phone A. The digits are sent in level 2 packets to the NCP.
64
66
The NCP knows Phone A (x123) and Phone C (x234) are not on the same level 2 network. The phone knows Phone C (x234) already has an IP address but Phone A (x123) does not.
68
The NCP grabs an IP address in the pool (e.g., reads out from memory) for use with devices on the same level 2 network as the NCP.
70
The NCP sends a level 2 packet to Phone A (x123) with the IP address A.A.A.A and instructs Phone A (x123) to use this IP address for the duration of the call.
The NCP instructs Phone A (x123) to talk to Phone C (x234) which is at IP address C.C.C.C.
72
74
Phone A (x123) grabs the IP address A.A.A.A and advises the local subnet (cluster) by broadcasting ARP messages to the local network.
76
Phone A (x123) sends Audio packets encapsulated as IP packets, to Phone C (x234). The source IP address of the IP packets is A.A.A.A and the destination IP address of the IP packets is C.C.C.C
78
Either Phone A (x123) or Phone C (x234) hangs up The phone sends this info to the NCP via a level 2 packet or level 3 packet (Phone A - x123) or via a level 3 IP packet (Phone C- x234).
80
The NCP instructs Phone A (x123) to terminate th call, stop sending IP audio packets to Phone C (x234), and that it no longer has the IP address A.A.A.A.

Fig. 6A

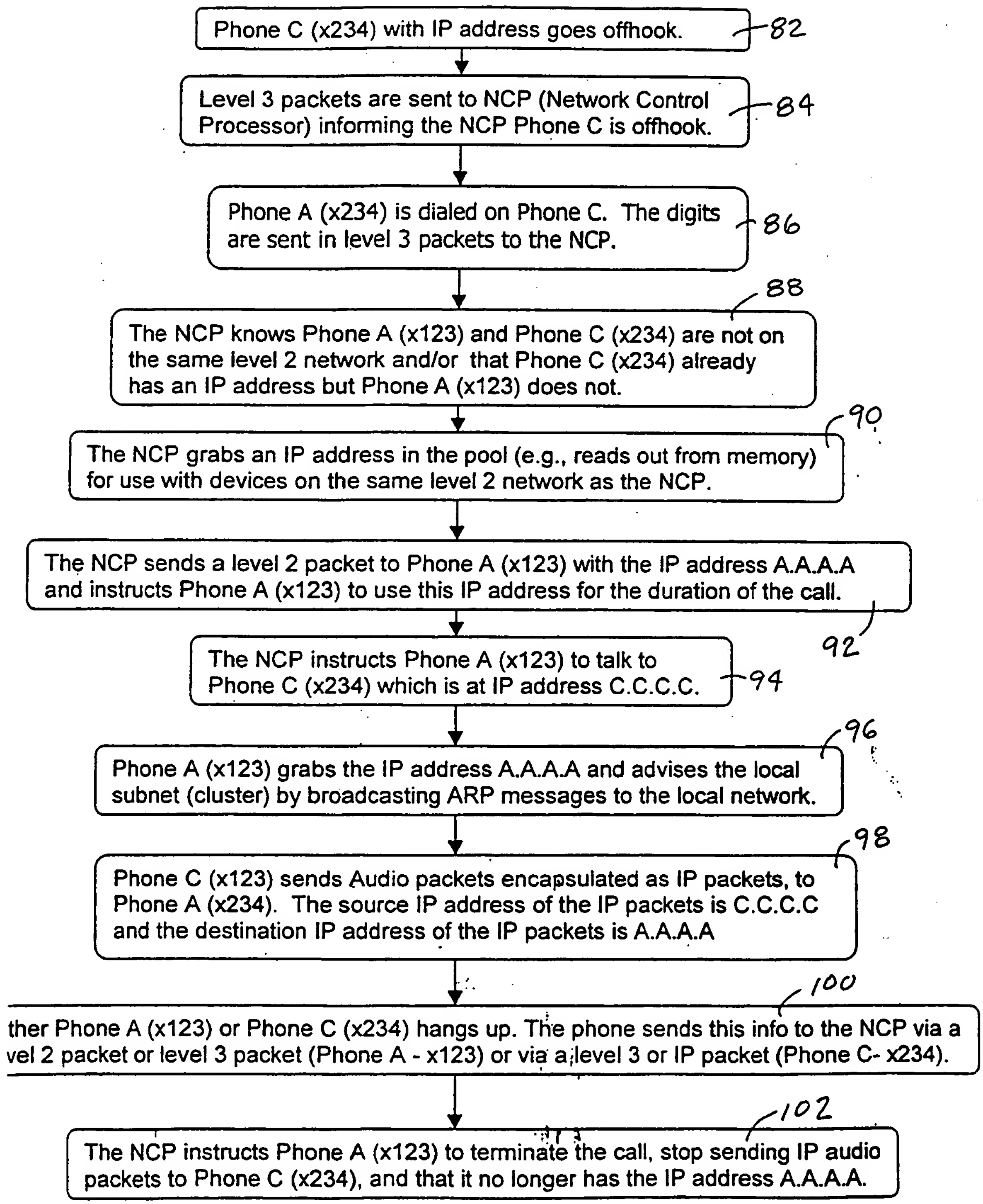
Phone C (x234) with IP address goes offhook.
82
Level 3 packets are sent to NCP (Network Control Processor) informing the NCP Phone C is offhook.
84
Phone A (x234) is dialed on Phone C. The digits are sent in level 3 packets to the NCP.
86
88
The NCP knows Phone A (x123) and Phone C (x234) are not on the same level 2 network and/or that Phone C (x234) already has an IP address but Phone A (x123) does not.
90
The NCP grabs an IP address in the pool (e.g., reads out from memory) for use with devices on the same level 2 network as the NCP.
The NCP sends a level 2 packet to Phone A (x123) with the IP address A.A.A.A and instructs Phone A (x123) to use this IP address for the duration of the call.
92
The NCP instructs Phone A (x123) to talk to Phone C (x234) which is at IP address C.C.C.C.
94
96
Phone A (x123) grabs the IP address A.A.A.A and advises the local subnet (cluster) by broadcasting ARP messages to the local network.
98
Phone C (x123) sends Audio packets encapsulated as IP packets, to Phone A (x234). The source IP address of the IP packets is C.C.C.C and the destination IP address of the IP packets is A.A.A.A
100
ther Phone A (x123) or Phone C (x234) hangs up. The phone sends this info to the NCP via a vel 2 packet or level 3 packet (Phone A - x123) or via a level 3 or IP packet (Phone C- x234).
102
The NCP instructs Phone A (x123) to terminate the call, stop sending IP audio packets to Phone C (x234), and that it no longer has the IP address A.A.A.A.

Fig. 6B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/24651

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : H04L 12/66
US CL : 370/352
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 370/352,389,392,401,402,403,404

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
USPTO's EAST (USPAT)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,708,655 A (TOTH, et al) 13 January 1998, Fig.1, paragraphs @ Col 9, Line 33, Col 1,line 42, Col 6,line 48, Col 7, lines 1-4)	1,2,5,8
Y	US 5,835,725 (CHIANG, et al) 10 November 1998 Abstract, Figs.4,5, elements 425,475,500, paragraph @ Col 5, lines 43,44)	1,5,6
A	US 5,159,592 A (PERKINS) 27 October 1992, fig.2, col 4 lines 66 - col 5, lines 50.	1-19

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search 6 January 2000	Date of mailing of the international search report 02 FEB 2000
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703)305-3230	Authorized officer Fred Wolkow James R. Matthews Telephone No. 703 305 4892

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/24651

Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claim Nos.: 16
because they relate to subject matter not required to be searched by this Authority, namely:
PROCESS STEPS/ELEMENTS OF THIS DEPENDENT CLAIM (...ONE OF THE PHONE DEVICE AND ...
------...LEVEL 3 PACKET IF SENT BY ...) ARE NOT CLEAR.

2. ☐ Claim Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest ☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/24651

Continuation of B. FIELDS SEARCHED Item3: EAST ((pool or list or set or group) same ((internet or ip) adj address$2) same (allocat$3 or assign$3 or designat$3)) and 370/$ note: search broadened by substituting "and" for "same."

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CORRECTED VERSION*

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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09/325,906 4 June 1999 (04.06.99) US

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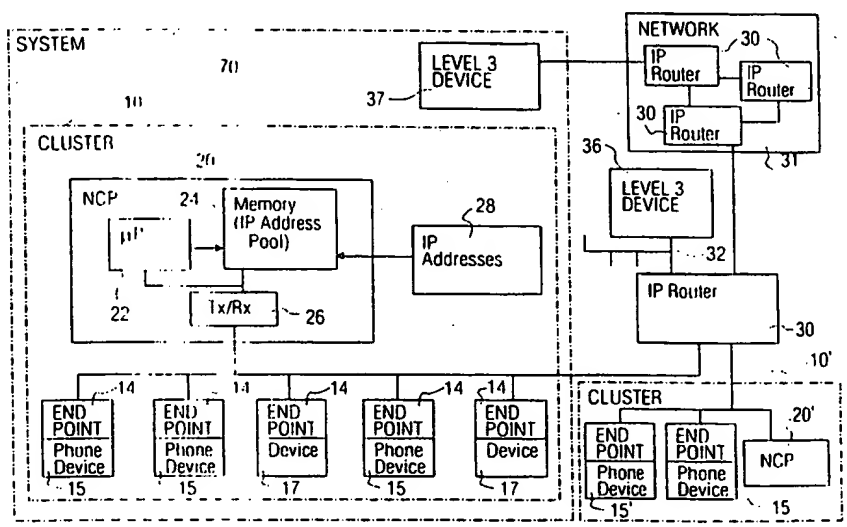
(74) Agents: MCGLEW, John, James et al.; McGlew and Tuttle, P.C., Scarborough Station, Scarborough, NY 10510-0827 (US).

(81) Designated States: AU, CA, GB, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
With amended claims.

(54) Title: DYNAMIC IP ADDRESS ASSIGNMENT



(57) Abstract

In a data network system (31, 70, 36, 30, 10') and/or process for communications between endstations (15', 17) which are routed through an IP network (30, 31) precious and distinctive addresses, typically IP addresses are not permanently associated with each endstation, but rather are only transiently related to some relatively versatile endstations (15, 17). Precious IP addresses are collected, dispensed and assigned to versatile endstations from a subnetwork-based pool of IP addresses (24, 28) according to network call like cycle events. At the start and then at the end of any call between a versatile end station and any other end station, a network controller (20) will perform assignment/dispensation from, and then return to, a pool of unique IP addresses such that even a versatile endstation has a unique IP address for the duration of the call.

*(Referred to in PCT Gazette No. 37/2000, Section II)

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Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

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MN	Mongolia
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ZW	Zimbabwe

DYNAMIC IP ADDRESS ASSIGNMENT

CROSS REFERENCE TO RELATED APPLICATION

This is a non provisional application claiming the benefit of provisional application 09/325,906 filed October 18, 1998.

FIELD OF THE INVENTION

The invention relates in general to IP address assignment as well as a telephone system which is operated using a data network, such as a local area network and more particularly to the use of such a system in both level 2 and level 3 network environments.

BACKGROUND OF THE INVENTION

Computer networks or data networks connect a plurality of devices to each other

using a network architecture. Most network architectures provide several different layers. Each layer is responsible for providing some service to the layer above and does this by using the services of the layer below. The open systems interconnection (OSI) reference model defines seven layers for computer networks. There is no special importance as to the number seven. However the reference model provides some guidance for designers. Protocols that are used for the various levels have evolved over time and some of the various layers have been subdivided into further layers.

Generally the first or lowermost level is referred to as the physical layer. This layer has responsibility to transmit unstructured bits of information across a link of the network. The physical layer deals with such problems as size and shape of connectors, assignment of functions to pins, conversion of bits to electrical signals, and bit-level synchronization. It is usual for several different types of physical layers to exist within a network and even for multiple different types of physical layers to exist within a node (also referred to herein as an end station or end point device), as each technology requires its own physical layer. For example, a node with an Ethernet attachment and an attachment to a 56Kb synchronous line will have implemented two different physical layers.

Layer two is generally considered the data link layer which has the responsibility to transmit chunks of information across a link. Level two deals with such problems as check summing to correct data corruption; orderly coordination of the use of shared media, as in a LAN (Local Area Network); and addressing when multiple systems are reachable, as in a LAN. The addressing is accomplished with so-called MAC (Media Access Controller) addresses. Specifically, each networkable device has assigned to it a unique MAC address for use at the so-called layer two. Devices can communicate with

each other based on the MAC addresses. Data packets may be switched based on MAC addresses. It is common for layer two links to implement different data link layers and for a node (or end point) to implement several data link layer protocols, one to support each of the different types of links to which the node is attached (as discussed above with regard to layer one).

Layer three is normally referred to as the network layer. Layer three has the responsibility to enable any pair of systems in the network to communicate with each other. A fully connected network is one in which every pair of nodes has a direct link between them. However, this type of topology is not used as it does not scale beyond a few nodes. Accordingly, in a more typical case, the network layer must find a path through a series of connected nodes, the nodes along the path must forward packets in the appropriate direction. The network layer deals with such problems as route calculation, packet fragmentation and reassembly (different links in the network have different maximum packet sizes), and congestion control.

With the more frequent use of the Internet, Internet protocol (IP) addressing has been more extensively used at layer three. Routers and other layer three devices typically have address lookup tables wherein a packet which has an IP encapsulation (namely an IP address added to the packet) can be directed or routed by a router (or a network of routers) based on the use of a lookup table of route entries which represent individual IP addresses and groups of IP addresses -often bit contiguous (there is a commonality between leading bits of addresses).

Computer and telephone networks have historically been provided based on separate physical infrastructures and are normally separately managed. Computers which

are connected to the global Internet require IP addresses in order to communicate with other computers around the world. For this reason, layer three devices often use layer three IP addressing. These same computers can communicate on local networks without the need for IP addresses by using layer two switching using MAC addresses. However, typically, IP addresses are used and layer three routing and interconnection is provided.

Telephone systems have typically been provided as PBX systems or similar systems with line cards or other connections to the public phone system and with various telephones connected back to a central exchange device. The PBX systems include digital systems wherein a proprietary protocol or other some phone-based protocol is used. With such systems, most telephones do not have an IP address. Trying to converge the infrastructure such that the telephone system operates over a computer network poses some challenges, particularly with regard to addressing. If a company were to replace its telephone system with a new IP-based phone system, they would need to double (or more) the number of IP addresses they use. Thus, efficient management of the limited IP version 4 address space is an important consideration for such a converged infrastructure.

An IP address allocation scheme referred to as DHCP (Dynamic Host Configuration Protocol) is known. This protocol functions for environments which are primarily at level three. With DHCP the devices lease an IP address for their primary method of communication. While such DHCP leases can be short term in nature, the lessee usually cannot do anything meaningful without the IP address. This presents the problem of not being able to have communication within the subnet based on MAC addresses or the like.

Typically level three packets are encapsulated in IP (Internet Protocol) and may

be routed by routers based on IP addresses. MAC addresses, which are globally unique, may be used for switching at level two, namely switching based on MAC addresses. Typically with IP encapsulation, the destination and source IP addresses are provided.

By utilizing level two functions, a system may be provided which is able to communicate without an IP address and hence does not require an IP address for normal usage. However as the traffic is directed to outside of the local net, it is necessary to use the router MAC address and then use IP encapsulation including both the IP destination address and IP source address. The DHCP system is not optimized for systems relying primarily on level two addressing and a system which primarily uses level two addressing presents the problem as to functioning in a routed level three environment.

SUMMARY AND OBJECTS OF THE INVENTION

It is an object of the invention to provide a system which operates using a computer network infrastructure wherein a plurality of devices at network endpoints are connected via the network (a subnet) and at least some of the devices do not have Internet protocol (IP) addresses. For traffic beyond the subnet, or other traffic that requires an IP address, a network control processor (NCP) is provided which allocates IP addresses to the device on an as-needed basis.

The devices connected via the network (a subnet) wherein at least some of the devices do not have Internet protocol (IP) addresses are preferably telephone devices. The telephone devices may be e.g. phones, TLIMs (Telephone Line Interface Modules), PSTN (Public Switch Telephone Network) gateways, T1 gateways, H323 gateways, etc., computers etc. In this text, the term telephone device is intended to include a telephone

unit that has a handset and has a transmitter and receiver function for placing audio level two (2) packets (e.g., packets with MAC addresses) on a network and for receiving such data packets. The telephone device may also be a computer that has a sound card for audio input and output and a connection to the network (e.g., via a network interface card which includes the transmitter and receiver function for placing level two packets on the network and for receiving such data packets). The telephone device may also be a TLIM or other device for converting one format of telephone signaling to another form of telephone signaling (e.g., proprietary) and may also be for audio format conversion (one packet format to another) and for converting an audio format to another -e.g., analog acoustic to a digital packet).

The system of the invention eliminates the need for a large number of IP addresses to be allocated, namely an IP address allocated to each end point, such as each telephone device attached to a network. Instead, a pool of IP addresses is maintained wherein the total number of IP addresses in the pool is preferably less than the total number of phone devices connected to the subnet. The allocation on an as-needed basis reduces the complexity and overhead of managing the IP address space.

According to the invention a system is provided, which has features for the management of IP addresses. The system has a number of devices located on the same level two network (a subnetwork or cluster of devices which can communicate with level two addresses). At least some of the devices have no IP address. Occasionally, one or more of these devices needs to communicate with a device located on a different subnet (an IP subnetwork) or a device with an IP address on the subnet. Communication between two of the devices using IP addressing may also be provided.

One device of the subnetwork or "cluster" can be a controller for the subnet. The controller may also be connected to the network. The device controller is either active in handing out IP addresses or only responds to IP address requests. The device controller may or may not be the same device which controls other features and functions of the overall system (the system may include for example the cluster itself as well as other devices not located on the same level two network).

According to a preferred embodiment of the invention, the device controller or network control processor (NCP) knows the status of all the devices in the system. Specifically, the devices are connected to allow communication between devices. The NCP can note the desire of any particular device to communicate with other devices in the system but which are not in the cluster, or in a wholly separate system (which may or may not be on the same level two network but are connected to the cluster). The system preferably provides that the devices direct requests to the NCP. Upon the receipt of such a request, the device controller allocates to the device an IP address from a pool of IP addresses designated for the cluster. Such a pool of IP addresses may be maintained in a memory associated with the device controller. Upon notification that the device no longer needs to communicate outside the cluster, the device controller reclaims the IP address and returns the address to its pool for allocation to another requesting device. The device controller may use another protocol (DHCP) from another controller or DHCP server to allocate this pool of IP addresses. The provision of the IP address can be automatic or manual DHCP can be used by the NCP to obtain multiple IP addresses wherein the lease for such addresses can be renewed as needed.

The preferred embodiment of the invention is thus able to allow communication

without an IP address, within the cluster and hence does not require an IP address for normal usage. In this normal function, the system communicates exclusively via level two protocols when possible, and only uses level three protocols when necessary. If a level two device (with no IP address and only a level two address) needs to communicate with a level three device, the level two device is assigned an IP address for the duration of the call. The IP address is revoked at call termination or at some point after the call terminates. Accordingly, the pool of IP addresses may be maintained small and the number of IP address space resources required for the overall system is a function of the maximum number of expected calls between routed networks (e.g., the number or requests for communication between a device on the subnet with no IP address and a device with an IP address and connected to the subnet), and is not a unitary function of the number of devices in the system. As a single device controller or network control processor can be designed to be switched at level two, then IP addresses are needed only when devices are making inter-domain calls (calls to be routed using a level three router to a different domain).

According to another embodiment of the invention, the device itself (e.g., phone or phone system in a computer) recognizes that it needs to communicate outside of the cluster, and makes a request to the device controller for an IP address. The device uses the IP address received for the duration of the communication, and releases the IP address back to the device controller at the end of the call. The device may or may not use an existing protocol such as DCHP to grab an IP address. Protocols such as DHCP can be used and allow the device controller (DHCP server) to be located on a different subnet than the entire cluster itself. In that case (no DCHP server on the same subnet) software

known as BOOTP relay agent can be installed or activated on a router to relay the level 2 DHCP request or level 2 request to the appropriate DCHP server or domain controller.

According to another aspect of the invention, a process for allocating IP addresses is employed with a system with devices which normally communicate at level two and require an IP address for communication via an IP- router to another cluster or subnetwork. The system utilizes a plurality of phone devices without IP addresses and a Network Control Processor (NCP) which controls level two communication between the devices. The process includes detecting when a phone (A), without an IP address, goes off hook. A level two packet is sent to the NCP, informing the NCP of the off hook state of the phone (A). A number for another phone (C) is dialed at the phone (A). The digits dialed are sent as a level two packet to the NCP. When the NCP detects that the phone (A) without the IP address and the phone (C) corresponding to the number dialed are not on the same level two network (and the phone dialed has an IP address but the phone that dialed does not have an IP address) the NCP accesses an IP address from an IP address pool maintained by the NCP. The pool is for use with devices on the same level two network as the NCP. The NCP then sends a level two packet to the phone (A) with one of the IP addresses from the pool and instructs the phone (A) to use the IP address for the duration of the call (e.g. A.A.A.A). The NCP also instructs the phone (A) to talk to the other phone (C) based on the known IP address (e.g., C.C.C.C). The phone (A) then grabs the IP address (e.g., A.A.A.A) and broadcasts an ARP (Address Resolution Protocol) message to the Local Area Network so as to advise the other devices on the local subnet. The phone (A) then begins to send audio packets, encapsulated as IP packets, to the other phone. The source IP address of the IP packets is e.g., A.A.A.A and the

destination IP address of the IP packets is e.g., C.C.C.C. Upon completion of the call, either phone (A) or the other phone (C) hangs up. The phone (A) sends its information to the NCP via a level two packet if it is phone (A) or via a level three IP packet or level two packet if it is the other phone (C). The NCP upon receiving the packet indicating the termination of the call instructs the phone (A) to terminate the call and stop sending IP audio packets to the other phone. The NCP also instructs the phone (A) that it no longer has the IP address which has been allocated.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and specific objects attained by its uses, reference is made to the accompanying drawings and descriptive matter in which preferred embodiments of the invention are illustrated.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

Figure 1 is a diagram showing system components according to the invention;

Figure 2 is a diagram showing the system according to the invention with a level 2 packet exchange between devices in a subnet or cluster;

Figure 3 is a diagram showing aspects of a call setup for an exchange of packets between telephones using level 2 addressing and level 2 protocols;

Figure 4 is a diagram showing a call setup using dynamic Internet protocol address assignment according to the invention;

Figure 5 is a diagram showing a call setup with a temporarily assigned IP address;

Figure 6A is a flow diagram for illustrating steps involving the assignment of an IP address; and

Figure 6B is another flow diagram illustrating steps involving the assignment of an IP address.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings in particular, the invention comprises a network system and process involving a plurality of interconnected devices defining a data network. The network is referred to as a subnetwork or cluster 10 and includes a physical connection 12 (such a connection may also be based on wireless interconnection schemes such as radio frequency RF connections and infrared (IR) connections) between end points 14. The end points include devices, which may be for example telephone units, computers, TLIMs or other telephone devices 15. The end points also may have other devices 17 besides telephone devices. The devices may include a network interface with a transmitter and receiver. The phone devices 15 also include a processor and also generate audio data packets. At least some of the devices 15 and 17 have no IP address. Preferably all of the devices have a MAC address for communication over the network 12 with level two packets (e.g., destination and source address). The end points 14 may have devices for interconnection to other subnetworks or networks such as routers 30, bridges or switches. The cluster 10 according to a preferred embodiment of the invention also includes a network control processor (NCP) 20. The Network Control Processor 20 monitors traffic over the network 12 and/or receives packets from other devices. The network 12 can implement any one of numerous protocols such as ETHERNET (IEEE802.3 using for

example 10 base T or other physical media schemes). Although the preferred embodiment of the invention is based on an ETHERNET type network, the invention can be practiced using various physical layers and various layer 2 protocols. The preferred embodiment relates generally to a Local Area Network as the cluster 10 however other networks including Wide Area Networks, networks established based on the public phone system and/or the Internet they also employ the system. However, the invention primarily provides the cluster 10 wherein most communication between the end points 14 may take place using level 2 addressing (e.g. the MAC addresses) associated with each device or end station at each end point 14. Further, the invention is not limited to a phone system using the subnet. The invention also applies to other devices with a MAC address and with no IP address, which can send and receive level two packets (e.g., packets using MAC addressing).

The NCP 20 monitors traffic over the network and controls communication between end points 14 which involves audio communication, namely telephone communication with data packets. Besides the telephone communication using level 2 packets, exchanged between end points 14, the network interconnection 12 may be used for data exchange between computers, using the ETHERNET protocol as mentioned above.

The NCP 20 includes a processor or an intelligent device 22 as well as a transmitter and receiver 26 and a memory 24. The memory 24 establishes an IP (Internet Protocol) address pool wherein a plurality of IP addresses are maintained or accessed. The IP addresses are first obtained in a known manner and input into the memory as shown at 28. The number of IP addresses which are provided in the memory IP address

pool 24 depends upon the anticipated or expected calls between an end point 14 and an end point or device which is not on the local subnet or cluster 10.

The devices at end points 14 include telephone units which have no IP address. These telephone units do have a MAC address which facilitates layer 2 communication between any of the various phones at end points 14 and the NCP 20. As shown in Figure 2 a telephone device A with no IP address can initiate a telephone call to device B which also has no IP address wherein these devices are connected over the network connection 12 of the local subnet or cluster 10. To set up the call the NCP 20 sends a packet on the network connection 12 which includes the device A MAC address and signals device A to talk directly to device B using device B's level 2 address. Similarly, the NCP 20 signals device B to talk directly to device A using device A's level 2 address. The packet exchange between device A and device B occurs at level 2 wherein the packets include the MAC addresses, namely the destination and source MAC address.

As shown in Figure 4, the system of the invention also allows communication between a phone 15 or device 17 at an end point 14 and a phone or device 36 connected to another network, subnet or the like wherein the subnet or cluster 10 is connected to the other network or subnet via a level 3 router (IP router) 30 or routers 30 or a network of routers 31. Specifically, the IP router 30 as shown in Figure 1 is a level 3 device which for example may maintain a lookup table of IP addresses or groups of IP addresses for determining where a packet is to be forwarded to. Normally, the term router refers to a device which can handle level 3 addresses. Most typically, the level 3 addresses use the so-called IP (Internet Protocol) addressing. Switches also provide a similar function and level 2 switches are known which provide switching using level 2 addressing. Traffic to

an entity outside a devices subnet 10 is provided with the MAC address to the router 30 with an IP address inside the packet. The router then can encapsulate the packet with the destination IP address and source IP address. The IP router may also be considered a level 2/level 3 interface. Devices know whether the destination of a packet is on the same subnet or different subnet based on a subnet mask which can be maintained by the intelligent devices. A function of a source device IP address, a source devices subnet mask, a destination devices IP address is to indicate whether or not a destination is on the same subnet, level two network or logical level 2 subnet as the source. When a device communicates to another device on a same subnet using IP an ARP request is generated. The source device responds with its own hardware address (MAC) and the two devices can communicate at level 2 or level 3 as both source and destination have MAC and IP address. The IP router has knowledge that some end-point or device on the subnet has an IP address corresponding to the received ARP broadcast. The router or destination device fills in its own hardware address and responds to the requesting device. It may also put the hardware address in its own ARP table. The ARP request involves a response of devices on the same net. Also, intermediate devices may make proxy responses for devices not on the net. Virtual LAN concepts can be used with the system of the invention.

As shown in Figure 4, where a device with no IP address such as device A at end point 14 wishes to set up a call with a device on a different subnet or connected via the level 3 interface (the IP router 30) the NCP 20 must first assign it one of the IP addresses from the IP address pool 24. The call setup is shown in the diagram of Figure 5. The NCP 20 assigns device A with a level 3 address by sending a level 2 packet to device A.

NCP 20 then signals device A to talk to device C using device C's level 3 address. Similarly, the control unit signals to device C to talk directly to device A using device A's temporary level 3 address. The packet exchange between devices A and C occurs at level 3 via the router 30 (or network 32 with a network of routers, subnets etc.). When the call is done, the NCP tells device A and C to terminate the call. Then, the NCP 20 revokes device A's level 3 address.

As to the router 30, the router may assign the temporary IP address to a particular devices MAC address in its ARP lookup table, but this may be changed during subsequent calls.

Figure 6A shows a flow diagram of process steps involved in a call which requires the assignment of an IP address as discussed above.

The process of the invention is initiated at 60 as the phone A, namely a device 15 in the subnet or cluster 10 which has no IP address, has its status changed to off-hook. This may be for example by lifting a handset or otherwise actuating the phone A. Phone A is at an end point 14 connected via network connection 12 and provided in a subnet or cluster 10. The change of status to off-hook results in level 2 packets being sent to the NCP 20 informing the NCP 20 that phone A is off-hook. This is shown in the flow diagram at number 62. Number 64 shows the subsequent state wherein phone C (for example with number 234) is dialed on phone A. This results in the digits being sent in level 2 packets to the NCP 20. The subsequent step 66 is shown wherein the NCP 20 knows that phone A (at number 123) and phone C (at number 234) are not on the same level 2 network. The NCP 20 knows that phone C (at number 234) already has an IP address but that phone A (at number 123) does not have an IP address. The subsequent

step at 68 involves the NCP accessing an IP address from the address pool 24. The processor 22 can use any one of a number of algorithms for accessing the IP address including accessing the next available IP address. Another algorithm can be implemented if there are no IP addresses available. However, typically a number of IP addresses are available and the NCP signals to the IP address pool 24 to read out an IP address from memory which is to be assigned to one of the devices on the same level two network as the NCP 20. At the subsequent step 70 the NCP 20 sends a level two packet to phone A with an IP address read out from the IP address pool (e.g. A.A.A.A) and instructs phone A to use this IP address for the duration of the call. At the subsequent 72 step the NCP 20 instructs phone A to talk to phone C (number 234) which is at IP address C.C.C.C. (see also Figures 4 and 5). At the subsequent step 74 phone A (number 123) grabs the IP address A.A.A.A and advises the local subnet (cluster 10) by broadcasting an ARP message to the local network. That is, a level 2 packet is sent addressed to each end point 14 of the subnet 10 using the address resolution protocol (ARP). At the subsequent step 76 the phone A sends audio packets encapsulated as internet protocol packets to phone C (at number 234). The source IP address of the IP packets is A.A.A.A and the destination IP address of the IP packets is C.C.C.C. This is received at the interface or IP router 30 which forwards the packets to the subnet 50 based on the destination IP address. In the opposite direction the phone C sends audio packets encapsulated as IP packets to the phone A (at number 123). The source IP address of the packets is C.C.C.C and the destination IP address of the IP packets is A.A.A.A. Based on the address resolution protocol broadcast the router 30 knows that an entity on the subnet or cluster 10 has the IP address of the earlier ARP broadcast. Packets are exchanged during the

phone conversation as shown for example in Figure 5. Subsequently the process continues to step 78 wherein either phone A or phone C hangs up. The phone that hangs up sends this info to the NCP 20 via a level 2 packet or via a level 3 IP packet (in the case of phone A) or a level 3 IP packet (in the case of phone C). The NCP 20 then instructs phone A to terminate the call, to stop sending IP audio packets to phone C and it indicates that it no longer has the IP address A.A.A.A. This last step is shown at 80 in Figure 6.

The system of the invention also allows a phone device with an IP address to call a phone device or other device (15,17 etc.) which has no IP address. The process is similar to the process described with reference to Figure 6A. As shown in Figure 6B a phone C (x234) with an IP address goes off hook at shown at 82. As indicated at 84, phone C (x234) sends level three packet to NCP 20 informing the NCP that phone C is off hook. Phone A is dialed at 86. The digits are sent in level three packets to be NCP 20. The NCP 20 knows that phone C has an IP address and knows that phone A (x123) has no IP address as indicated at step 88. Next, the NCP 20 grabs an IP address from the address pool 24 as indicated at 90. As shown at 92 the NCP 20 sends a level two packet to phone A with the IP address (e.g. A.A.A.A) and instructs phone A to use this IP address for the duration of the call. At 94 the NCP sends a level 2 packet to phone A instructing phone A to talk to phone C which is at a particular IP address (e.g., C.C.C.C). Phone A grabs the IP address and advises the local subnet by broadcasting ARP messages to the local network as indicated at 96. Phone A and phone C exchanged audio packets encapsulated as IP packets as indicated at 98. Either phone A or phone C terminates the call as indicated at 100. The NCP 20 instructs phone A to terminate the call, to stop sending IP audio packets to phone C and that it no longer has the address that was

assigned (e.g. A.A.A.A) as indicated at 102.

The process of the invention for using the system of the invention can also provide phone devices on the same subnet with IP addresses for communication using level 3 packets. The invention is not limited in any way to the phones or other devices being on different subnets. Either or neither of the phone devices or other devices may have no IP address. The NCP may assign in IP address to either phone device or other device. Even though it is advantageous to provide communication with level two packets, communication on the same subnet may be provided with level three packets.

According to another embodiment of the invention the system includes devices which can be in a single cluster 10 or can be distributed (in multiple clusters or individual devices or a combination thereof), all logically associated with the same NCP 20 (see Figure 1). For example, the level 3 device 37 in Figure 1 can be logically part of a system 70 controlled by NCP 20.

According to yet another embodiment of the invention, the system of the invention can be used in two wholly separate systems controlled by two separate NCPs 20, 20', respectively, wherein a phone device 15 in one system which does not have an IP address may wish to contact a phone device 15' in a different system or subnet 10' which also does not have an IP address. The NCP 20 follows a procedure in which:

1) The calling phone device 15 is activated and dials a number which indicates the destination phone device 15' directly (unified/universal dial plan), or which maps to a specific system (system code) and then to the phone device 15' on that system (system-specific extension).

2) The NCP 20 recognizes that the number dialed is not a phone device within its

system, and determines the system which controls the destination phone device 15' (either by looking up the system code in a local database or by contacting some external device which can perform the mapping).

3) In an exchange of signaling messages, the NCP 20 for the system for the calling phone device contacts the NCP 20' for the system of the destination phone device and indicates to the other NCP 20' that the source device 15 is trying to reach the destination phone device 15'.

4) Prior to or during this exchange of signaling messages, the NCP for the system of the source (calling) phone 15 assigns an IP address to the source phone 15, and passes this information to the NCP 20' for the system of the destination (called) phone device 15'.

5) During the exchange of the signaling messages, if the destination phone device is activated, the NCP for the system of the destination device assigns the destination phone device an IP address and passes this information back to the NCP for the system of the calling device.

6) If the destination phone device 15' does not answer and the source phone device 15 also hangs up prematurely, an IP address may or may not be assigned to the source phone device 15. The preferred method is that the IP address assignment happens when the call is connected to the destination phone device 15' or audio recording device (i.e., voicemail on the destination system).

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles.

WHAT IS CLAIMED IS:

1. A system for data networks, the system comprising:

a network interconnecting a plurality of end station devices, each end station device having a level 2 address and some or all of said end station devices having no assigned Internet protocol address;

a network controller connected to said network interconnection, said network controller, said network interconnection and said end station devices cooperating to define a subnetwork with devices communicating in the subnetwork using level 2 packets;

an IP address pool associated with said network controller, said IP address pool corresponding to a plurality of IP addresses, said network controller assigning one of said IP addresses to one of said phones upon a communication being initiated which requires or involves level 3 addressing.

2. The device according to claim 1, wherein said all of said end station devices having no assigned Internet protocol address are telephone devices.

3. The device according to claim 1, wherein the number of IP addresses provided by said IP address pool is less than a number of said some or all of said end station devices having no assigned Internet protocol address.

4. The device according to claim 1, wherein said network is a subnetwork and wherein said assigning of an IP address by said controller occurs upon a communication

being initiated which involves a device on said subnetwork and a connection by an interface to a device not on said subnetwork.

5. The device according to claim 4, further comprising a level 3 interface connected to said subnetwork for providing level 3 connections between said subnetwork and a network or network devices connected to said interface.

6. The device according to claim 1, wherein the network controller establishes telephone calls between phones as end station devices based on packets exchanged between end station devices with level 2 MAC addresses only.

7. The system according to claim 1, wherein the network interconnection provides an ETHERNET type network connection.

8. A system according to claim 1, wherein at the termination or subsequent to the termination of the call the device which had been assigned the IP address from the IP address pool no longer has the IP address.

9. A process for operating a telephone system using a data network with a network connection between end points with phone devices connected at respective end points and a network controller connected to the network, the phone devices and network controller each having a unique MAC address, the process comprising:

providing telephone communication between phone devices using the controller

to initiate the sending of packets between devices which are to communicate, using MAC addresses only;

providing an IP address pool which can be addressed by said network controller, said IP address pool having a number of IP addresses which is less than a number of phone devices connected to the network; and

upon a phone device connected to the network initiating a phone call to a device not connected to the network, assigning one of said plurality of IP addresses to the phone device.

10. The process according to claim 9, wherein said step of initiating a phone call to a device not on the network include sending a packet with a MAC address only from a phone device which goes off hook, informing the network controller of the off hook status;

dialing at the network phone device a number which corresponds to a device which is not on the subnetwork resulting in sending a level 2 packet to the network controller indicating the number of a device not on the subnetwork;

and at the network controller determining that the phone device which has dialed and the phone device dialed are not on the same level 2 network and determining that the phone device dialed has an IP address and the phone device which has dialed does not have an IP address.

11. The process according to claim 9, wherein a phone device with an IP address calls a phone device without an IP address and the process includes generating a broadcast

ARP (Address Resolution Protocol) message.

12. The process according to claim 9, wherein said step of accessing the IP address pool includes obtaining an IP address from the address pool and sending a packet with a MAC address only from the network controller to the phone device, which packet includes the IP address for instructing the phone device to use the IP address for the duration of the call and instructing the phone device to communicate with the other phone device which has a particular IP address.

13. The process according to claim 9, wherein a phone device with an IP address calls a phone device without an IP address and the process includes generating a broadcast ARP (Address Resolution Protocol) message.

14. The process according to claim 9, further comprising upon receiving an IP address packet from the network controller, the phone device broadcasts an ARP message to the local subnetwork indicating that the phone device has the IP address which the network controller has assigned to it; and subsequently sending audio packets, encapsulated as IP packets to the other phone device wherein the IP source address is the address assigned to the phone device and the destination IP address is the IP address of the other phone device.

15. The process according to claim 9, wherein each phone device has no IP address such that two IP addresses are assigned by the NCP for a call and the process includes

generating a broadcast ARP (Address Resolution Protocol) messages for each phone device.

16. The process according to claim 9, wherein upon one of the phone device and the other phone device hanging up, the phone device which hangs up sends a packet to the network controller wherein the packet is a level 2 packet of sent by the phone device and the packet is a level 3 packet if sent by the other phone device.

17. The process according to claim 9, wherein upon termination of a call, the phone device stops sending IP audio packets to the other phone device and the phone device no longer has the IP address assigned to it by the network controller.

18. A process for operating a system using a data network with a network connection between end points with devices connected at respective end points and a network controller connected to the network, the devices and network controller each having a unique MAC address and at least some of the devices not having a permanently assigned IP address, the process comprising:

providing communication between devices using the controller to initiate the sending of packets between devices which are to communicate, using MAC addresses only;

providing an IP address pool which can be addressed by said network controller, said IP address pool having a number of IP addresses; and

upon a device connected to the network initiating a communication to a device

wherein one or both devices have or require an IP address for communication or if communication is desired using IP addressing, assigning an IP addresses from said pool to one or both of said devices.

19. The process according to claim 18, wherein said step of initiating a communication to a device includes:

sending a packet with a MAC address only, from a device for informing the network controller of the desire to initiate communication with another device; and

at the network controller determining that one or both of the devices to be involved in the communication has or requires an IP address or that the device dialed has an IP address.

AMENDED CLAIMS

[received by the International Bureau on 18 February 2000 (18.02.00); original claim 16 amended; remaining claims unchanged (1 page)]

generating a broadcast ARP (Address Resolution Protocol) messages for each phone device.

16. The process according to claim 9, wherein upon one of the phone device and the other phone device hanging up, the phone device which hangs up sends a packet to the network controller wherein the packet is a level 2 packet if sent by the phone device and the packet is a level 3 packet if sent by the other phone device.

17. The process according to claim 9, wherein upon termination of a call, the phone device stops sending IP audio packets to the other phone device and the phone device no longer has the IP address assigned to it by the network controller.

18. A process for operating a system using a data network with a network connection between end points with devices connected at respective end points and a network controller connected to the network, the devices and network controller each having a unique MAC address and at least some of the devices not having a permanently assigned IP address, the process comprising:

providing communication between devices using the controller to initiate the sending of packets between devices which are to communicate, using MAC addresses only;

providing an IP address pool which can be addressed by said network controller, said IP address pool having a number of IP addresses; and

upon a device connected to the network initiating a communication to a device

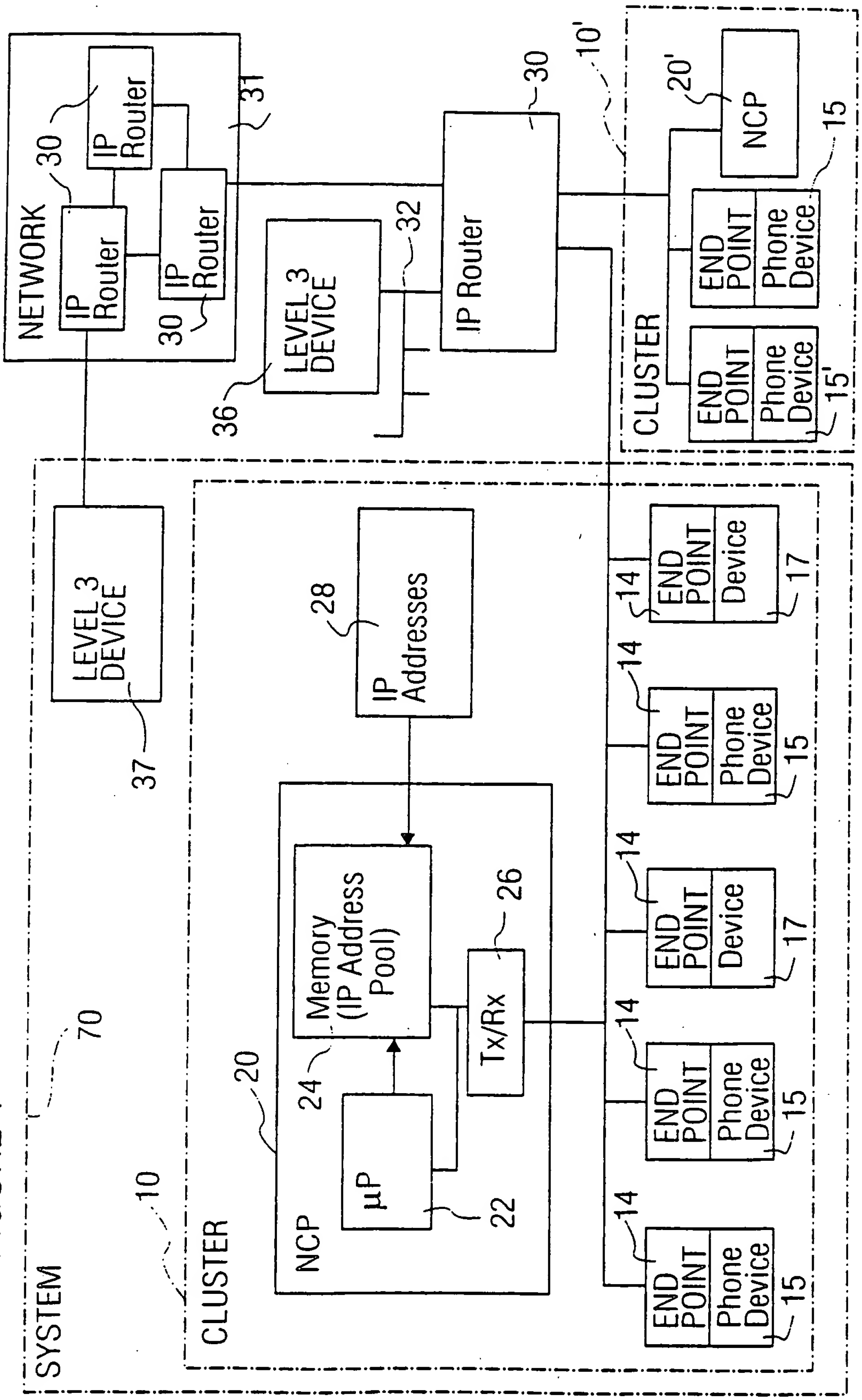
NETWORK
IP Router
IP Router
IP Router
30
30
30
31
LEVEL 3 DEVICE
36
32
IP Router
30
10'
CLUSTER
NCP
20'
END POINT
Phone Device
15
END POINT
Phone Device
15'
SYSTEM
70
LEVEL 3 DEVICE
37
CLUSTER
10
NCP
20
μP
22
24
Memory (IP Address Pool)
Tx/Rx
26
IP Addresses
28
END POINT
Device
14
17
END POINT
Phone Device
14
15

FIGURE 1

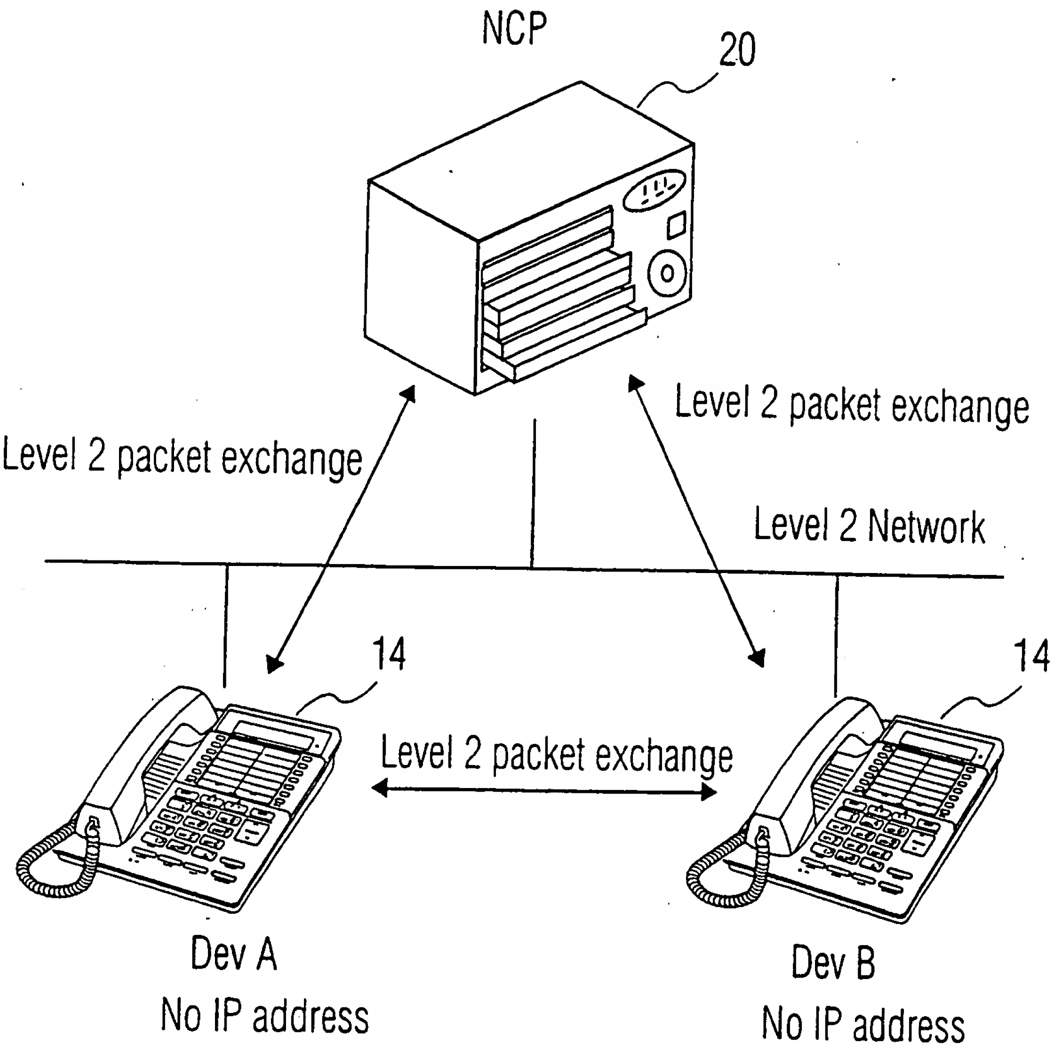
NCP
20
Level 2 packet exchange
Level 2 packet exchange
Level 2 Network
14
14
Level 2 packet exchange
Dev A
No IP address
Dev B
No IP address

FIGURE 2

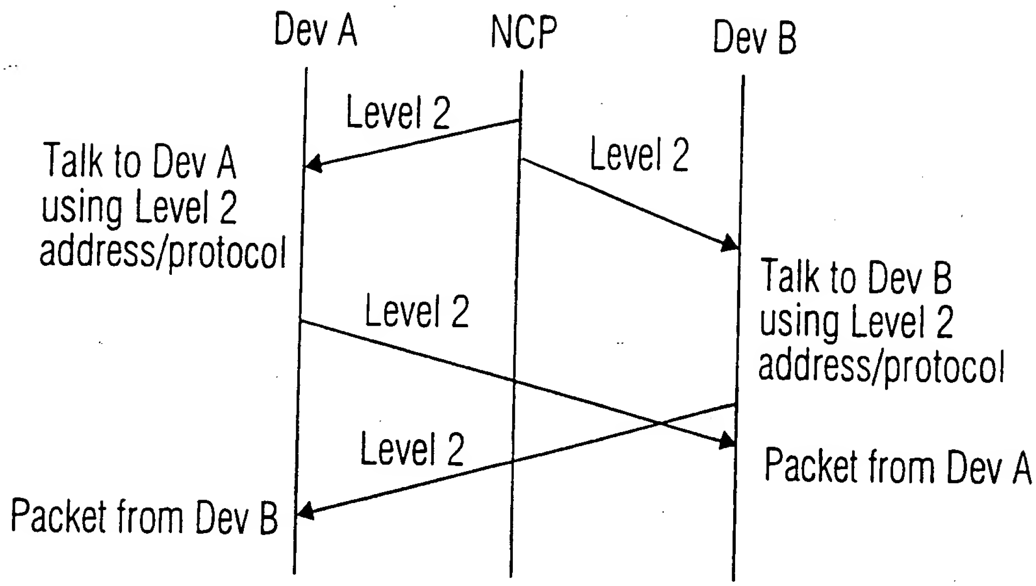
Dev A
NCP
Dev B
Level 2
Level 2
Talk to Dev A
using Level 2
address/protocol
Talk to Dev B
using Level 2
address/protocol
Level 2
Level 2
Packet from Dev A
Packet from Dev B

FIGURE 3

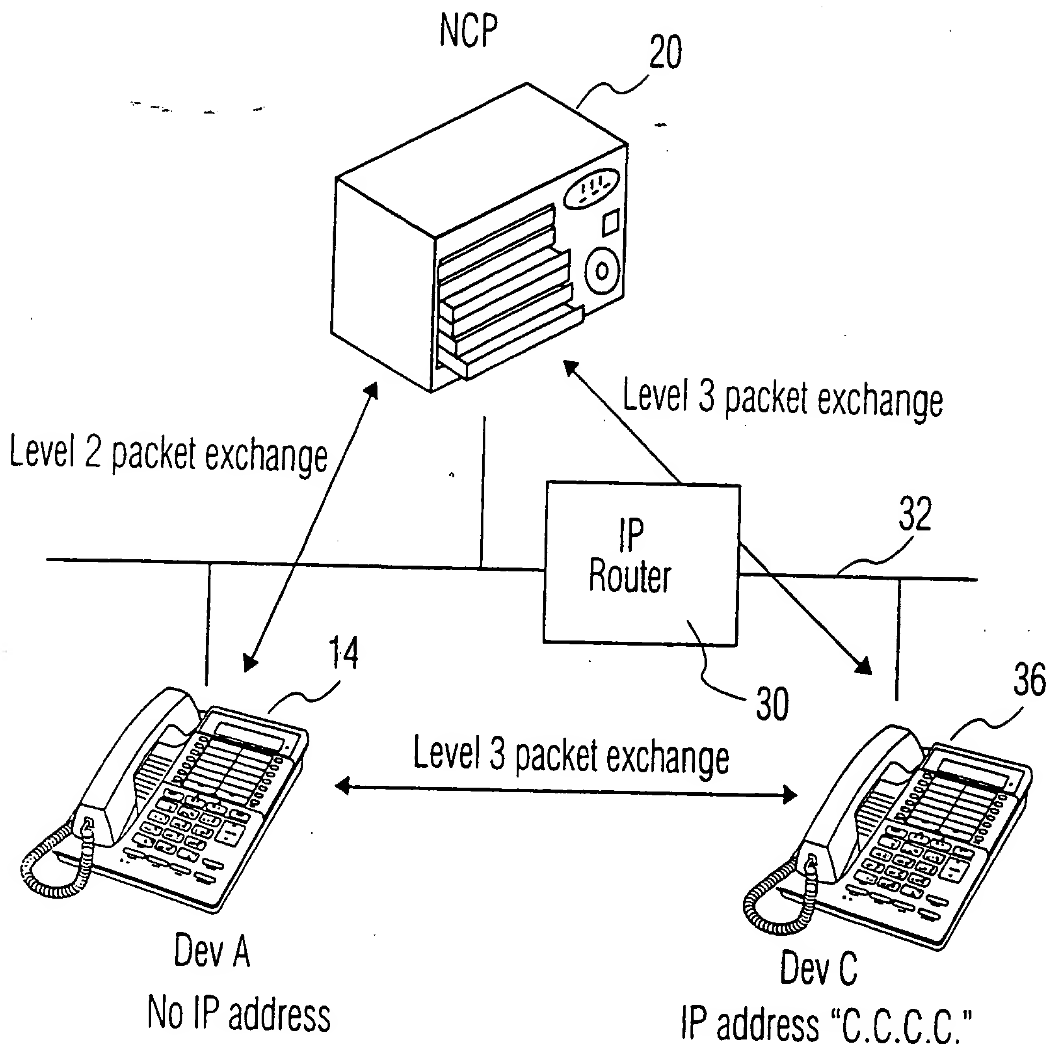
NCP
20
Level 2 packet exchange
Level 3 packet exchange
IP
Router
32
14
30
36
Level 3 packet exchange
Dev A
No IP address
Dev C
IP address "C.C.C.C."

FIGURE 4

In this call setup, the control unit assigns (via Level 2 communications) device A a Level 3 address. The NCP then signals device A to talk to device C using device C's level 3 address. Similarly, the control unit signals to device C to talk directly to device A using device A's temporary level 3 address. The packet exchange between devices A and C occurs at Level 3. When the call is done, the NCP tells device A and C to terminate the call. Then, the NCP revokes device A's Level 3 address.

29

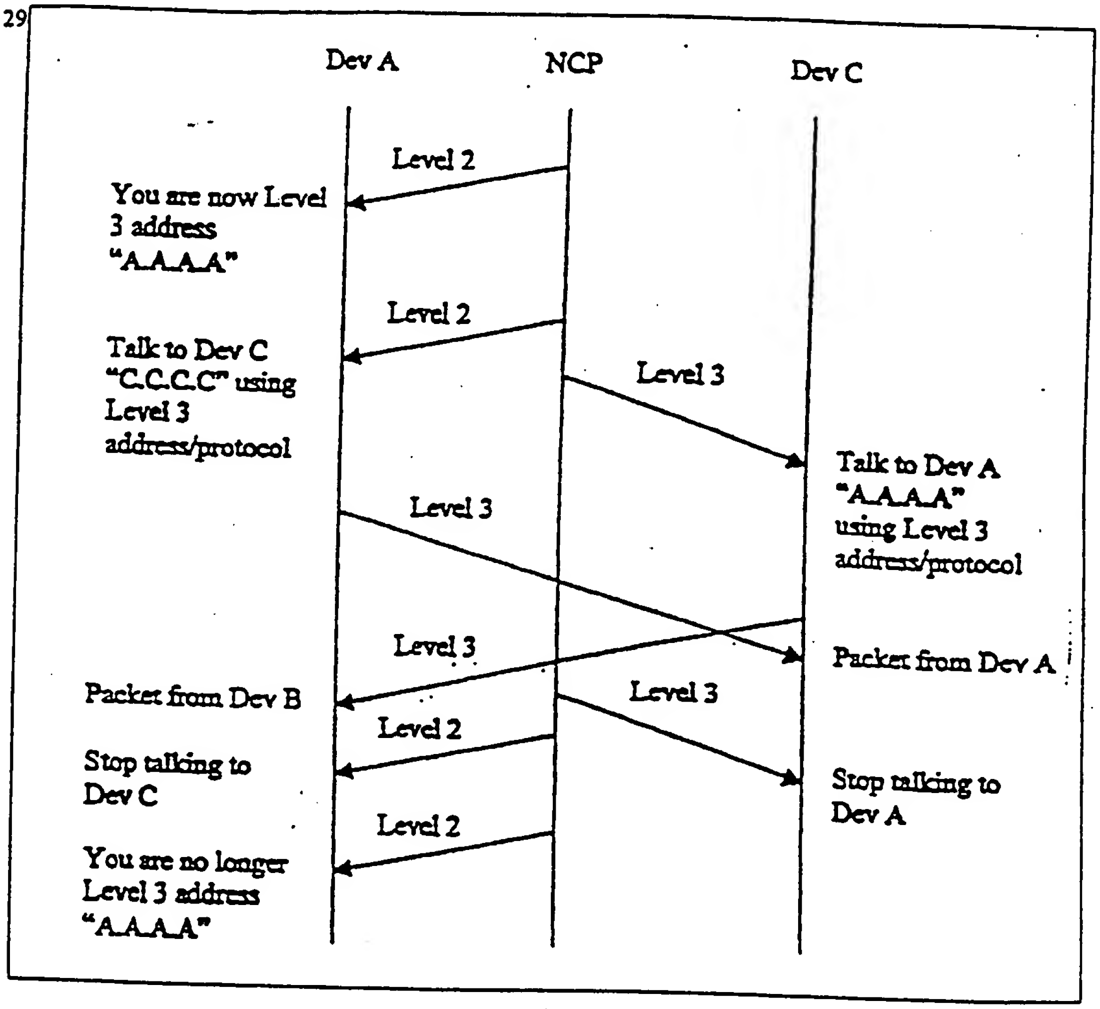

Fig. 5

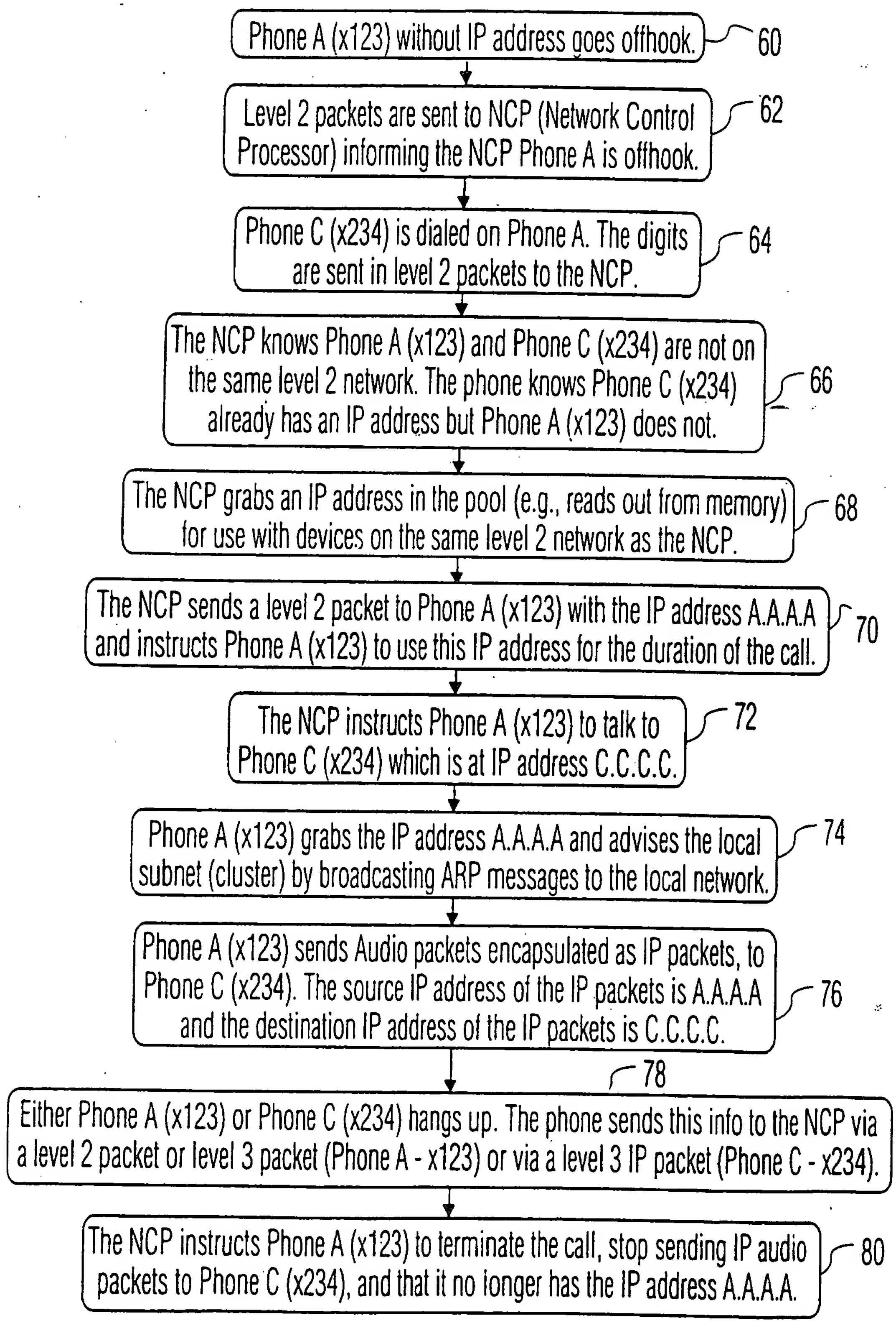
Phone A (x123) without IP address goes offhook.
60
Level 2 packets are sent to NCP (Network Control Processor) informing the NCP Phone A is offhook.
62
Phone C (x234) is dialed on Phone A. The digits are sent in level 2 packets to the NCP.
64
The NCP knows Phone A (x123) and Phone C (x234) are not on the same level 2 network. The phone knows Phone C (x234) already has an IP address but Phone A (x123) does not.
66
The NCP grabs an IP address in the pool (e.g., reads out from memory) for use with devices on the same level 2 network as the NCP.
68
The NCP sends a level 2 packet to Phone A (x123) with the IP address A.A.A.A and instructs Phone A (x123) to use this IP address for the duration of the call.
70
The NCP instructs Phone A (x123) to talk to Phone C (x234) which is at IP address C.C.C.C.
72
Phone A (x123) grabs the IP address A.A.A.A and advises the local subnet (cluster) by broadcasting ARP messages to the local network.
74
Phone A (x123) sends Audio packets encapsulated as IP packets, to Phone C (x234). The source IP address of the IP packets is A.A.A.A and the destination IP address of the IP packets is C.C.C.C.
76
78
Either Phone A (x123) or Phone C (x234) hangs up. The phone sends this info to the NCP via a level 2 packet or level 3 packet (Phone A - x123) or via a level 3 IP packet (Phone C - x234).
The NCP instructs Phone A (x123) to terminate the call, stop sending IP audio packets to Phone C (x234), and that it no longer has the IP address A.A.A.A.
80

FIGURE 6A

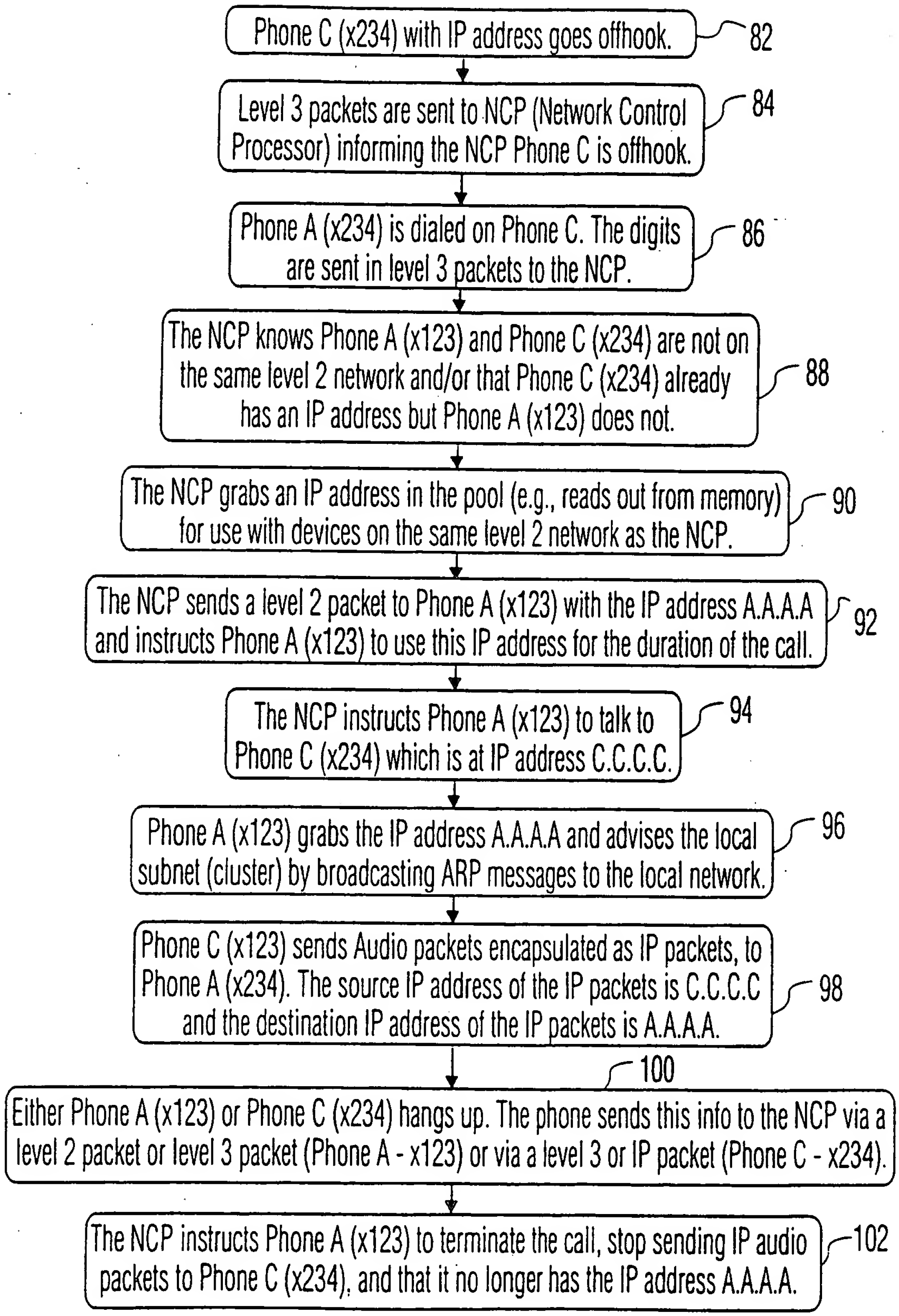
Phone C (x234) with IP address goes offhook.
82
Level 3 packets are sent to NCP (Network Control Processor) informing the NCP Phone C is offhook.
84
Phone A (x234) is dialed on Phone C. The digits are sent in level 3 packets to the NCP.
86
The NCP knows Phone A (x123) and Phone C (x234) are not on the same level 2 network and/or that Phone C (x234) already has an IP address but Phone A (x123) does not.
88
The NCP grabs an IP address in the pool (e.g., reads out from memory) for use with devices on the same level 2 network as the NCP.
90
The NCP sends a level 2 packet to Phone A (x123) with the IP address A.A.A.A and instructs Phone A (x123) to use this IP address for the duration of the call.
92
The NCP instructs Phone A (x123) to talk to Phone C (x234) which is at IP address C.C.C.C.
94
Phone A (x123) grabs the IP address A.A.A.A and advises the local subnet (cluster) by broadcasting ARP messages to the local network.
96
Phone C (x123) sends Audio packets encapsulated as IP packets, to Phone A (x234). The source IP address of the IP packets is C.C.C.C and the destination IP address of the IP packets is A.A.A.A.
98
100
Either Phone A (x123) or Phone C (x234) hangs up. The phone sends this info to the NCP via a level 2 packet or level 3 packet (Phone A - x123) or via a level 3 or IP packet (Phone C - x234).
The NCP instructs Phone A (x123) to terminate the call, stop sending IP audio packets to Phone C (x234), and that it no longer has the IP address A.A.A.A.
102

FIGURE 6B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/24651

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) : H04L 12/66
US CL : 370/352
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 370/352,389,392,401,402,403,404

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
USPTO's EAST (USPAT)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,708,655 A (TOTH, et al) 13 January 1998, Fig.1, paragraphs @ Col 9, Line 33, Col 1,line 42, Col 6,line 48, Col 7, lines 1-4)	1,2,5,8
Y	US 5,835,725 (CHIANG, et al) 10 November 1998 Abstract, Figs.4,5, elements 425,475,500, paragraph @ Col 5, lines 43,44)	1,5,6
A	US 5,159,592 A (PERKINS) 27 October 1992, fig.2, col 4 lines 66 - col 5, lines 50.	1-19

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 January 2000	02 FEB 2000

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Fred Wolkow James R. Matthews
Facsimile No. (703)305-3230	Telephone No. 703 305 4892

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/24651

Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claim Nos.: 16
because they relate to subject matter not required to be searched by this Authority, namely:
PROCESS STEPS/ELEMENTS OF THIS DEPENDENT CLAIM (...ONE OF THE PHONE DEVICE AND ... ------...LEVEL 3 PACKET IF SENT BY ...) ARE NOT CLEAR.

2. ☐ Claim Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claim Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest ☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

Continuation of B. FIELDS SEARCHED Item3: EAST ((pool or list or set or group) same ((internet or ip) adj address$2) same (allocat$3 or assign$3 or designat$3)) and 370/$ note: search broadened by substituting "and" for "same."